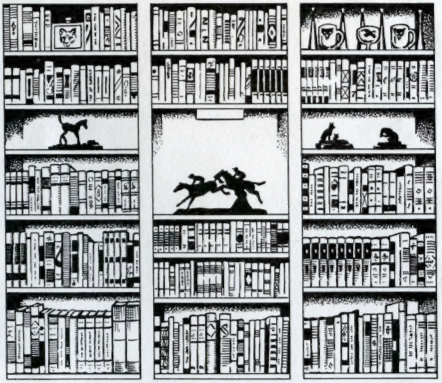
John Lovett



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JOHN AND MARTHA DANIELS

A TREATISE OF ARTIFICIAL FIRE-VVORKS

Both for VVarres and Recreation: with divers pleasant Geometricall obseruations, Fortifications, and Arithmeticall Examples.

In fauour of Mathematicall *Students*.

Newly written in FRENCH, and Englished by the Authour THO: MALTHVS.

Printed for RICHARD HAVVKINS, and are to be sold at his Shop in Chancerie lane neere to Serieants Inne. 1629.

William Nunn 1721 3/4

1759
1629
130

THE PREFACE Apologetique to the Reader.

ALthough that Warres haue beene authorized by the diuine powers, as witnesseth the new and old Testament, yet me thinkes I heare many nice, peeuish, and ignorant braines blaming me for setting downe to the view of the world (at a few leisurely houres) so many wayes and inuentions how to corrupt and destroy what nature and art striue to make, edifie and conserue, to whom I answer they haue the same reason to exclaim gainst iustice which hath found and or-

dained many meanes to abolish and ex-
terminate wicked offenders: for my in-
tention is here but onely to finde in-ven-
tions to confound and ruinate Rebells
and their habitations; that afterward
Empires, Kingdomes, and Common-
wealths may the better liue in peace and
tranquilitie: and what more is I hau
set downe perspicuously this Treatise o
Fire-workes, which many heretofore hau
written with confusion and great da-
ger, having pend large Volumes wi
most ample and idle discourses touchi
this subiect, whose names for modesti
sake I will not here set downe with an i
famous character to posteritie (as Mast
Robert Norton *hath done some f*
slight offenders names in the Preface
his translation of Vanos *works, wh*
he calleth his owne, hauing onely ad
seuen figures taken out of Thybou
bo

booke, and transposing the Authours workes to disguise it) that I bee not accounted amongst the calumniaters of this age, who write with serpents tongues spitting their venome vpon the silent and sleeping innocents gone before vs. But I will onely shew their errors in generall, that the learners may the better auoyde them: For in some you shall see prescribed all sorts of Apothecaries drugges for the compounding of Fire-workes, which are no more capable of fire then stones, earth, or mettle, as Adamant-stone, Verdigrease, Cristall, Vitriol, Salarmoniacke, Sublime, Mercurie, with a number of the like, which in the iudgement of ignorants may produce in Fire-workes wonderfull effects. In others you shall finde the coniunctions of combustible materials in such a sort or man-

ner disposed and ordered to such strange ends, that you would say they were set downe to make the Reader laugh, rather then for seruice of Fire-workes eyther for Warres or Recreation; as the meanes how to poyson an Armie in the wide Field by the smoake of an artificiall Ball, is it not to be thought a very prettie imagination, or else that the Ball ought to bee somewhat bigge; and afterward which is more ridiculous, you shall finde in the same Authours the same ingredients and mixtures prescribed for Fire-works for Pleasure and Recreation: which to me seemes strange, that the Fire-workes whose smoakes are so venemous even as to poyson Armies in the open Fields, shall bee also fit to burne in the middle of a Cittie or Towne a-

mongst

mongſt thouſands of people for Recreations: now all theſe idle conceites with a number of the like are printed in many new and recent bookes, the Authours whereof doubtleſſe haue ſet downe all theſe ridiculous inventions by ignorance, (thinking them good) and not of purpoſe for ſpight; and therefore they doe deſerue pittie rather then blame; as well as Maſter ROBERT NORTON, *(who hath erred onely in attributing another mans workes, and faults to bee his owne) and what is it that giues mee cauſe to thinke that all theſe haue erred by ignorance, is becauſe that all their workes are alike where that they doe ſpeake of Fire-workes. But reading theſe abſurdities with a great quantitie of others, which made mee take reſo-*

lution

lution to set my penne to paper, and shew to posteritie how and what way to auoyde their errours, having heere set downe the true rules and mixtures required for Fire-workes, both for VVarres and Recreation, with some few Geometricall obseruations necessarie for the practise of Fireworkes in warres; and also I haue added vnto it certaine rules and maximes of Fortifications, very requisite for Enginiers to haue in their memorie, with a compendious Arithmetike, hauing written the whole first in French at some broken houres whileſt I followed the warres; and bringing certaine coppies from the Presse to my speciall and very good friends; at whose requests I haue translated the same into English, that others might not translating it, mistake my meaning;

and

and the worke being already but of small commendations, they to make it of lesser. Adiew. London the 22. of May. 1629.

The

27
27
14

To the Authour.

THy Archimedean hand hath learnt to frame
Celestiall Meteors out of *Nitrous* flame:
And representes strange fires of differēt sorts
Suted to Martiall vse,& Courtly sports: (houres
So pleasing that great Kings haue spar'd some
To be spectators of thy golden showres.

The Thames and Seyne haue seen thy Balons fly,
From their affrighted bosomes to the skye:
Swift beyond all beliefe;as if thy ayme
Were,to restore *Prometheus* theft againe.(sunder
Were,when their force seems spent, breaking a-
They rain down stars,or els outroar the thunder.

The Roman Apotheosis I deeme,
Would still haue had a reuerent esteeme,
If they had vs'd their miracles of fire,
To mount their *Cæsars* soules,& beare thē higher
Then Eagles flight, but now they serue to raise,
The Pyramis and Trophe of thy praise.

And

And sure thou hast attain'd sufficient glory,
In perfecting the Pyrotecnique story:
Which some tooke vp on trust, & by concealing
Their creditors; made borowing to seem stealing.
But their fire's out, now thine hath pass'd the
For greater fires do extinguish lesse. (Presse.

WILLIAM BASTIAN *studious in Mathematicks.*

A TREATISE OF FIRE-WORKES.

for Warre.

CHAP. I.

TO imitate nature, our first and chiefest teacher, who far from error seemes to haue produced and brought forth all things by a curious and speciall order; without whose beautifull disposition the whole world had still continued in the most prodigious confusion of *Caos*, which displeased the pure aspect of the highest, eternall

and divine powers, being but a cloud or mixture of darkneſſe. My intention is here to inſtitute and obſerue an order, treating of euery thing one after another in his proper and conuenient place: beginning with artificiall Fire-workes, as the chiefeſt and principall cauſe which hath vrged me to take my penne in hand, the deſcription of thoſe which belong to warres, ſhall obtaine the firſt place, and next the Fire-workes for recreation or pleaſure, paſſing from theſe to many pleaſing Geometricall obſeruations, aſwell of Mecanical obſeruation, as by the ſines, tangents, & ſuccents, ioyning to them a moſt eaſie & ſuccent method to fortifie all places regularly and irregularly. And to conclude I will adde many

briefe

briefe and instructiue Arithmeticall examples.

Now to begin with the Fireworkes for warres, I will first describe the Morter-peece, and the vse thereof: that being an instrument, the most noble, the most vniuersal, the best of greatest effect, and of most wonderfull operation of all the instruments, the practise wherof may be vsed amongst Fireworkes for warres, for this instrument may serue for a Petard to split, breake and hurle down dores, gates or walles, likewise to massacre, teare in pieces, ouerthrow and confound assailants of any place or breach: and for diuers other most worthy offices, and accidentall occasions, which happen in the troubles of warres: whereof I will

not here make a long, weary, and tedious discourse, but in few words cleerely set downe the vse of this instrument for the shooting of diuers sorts of granads, stones, or other weighty burthens to ruine rebels, their habitations and dwelling places. Then first of all I will treat of the mettle, whereof this instrument ought to be made, and measures appertaining thereunto.

CHAP

Chap. II.

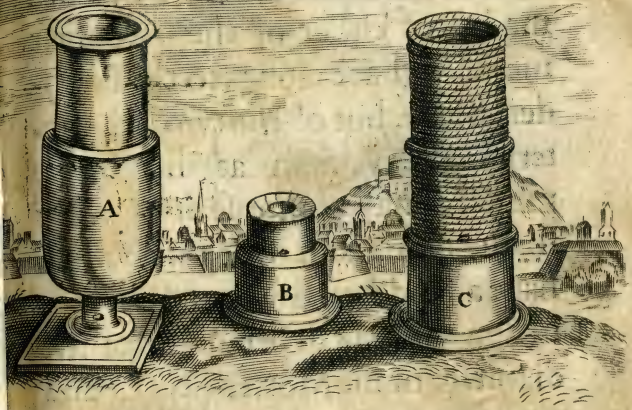
The manner how to make the Morter-Peece.

THis Instrument may bee made of diuers sorts of mettle or stuffe, according to the means, times and occasions which shall offer themselues to those who would make them, or cause them to bee made. The first and chiefest matter of all, is red copper, brasse and tinne, but very little of the two last, such as Canons are made of, without any other brickle or harsh mettle mingled with it, and beeing

made of this stuffe, let the measures following be observed. If the diameter of the calliber or bore be one foot, let the morter be two foot of length, & let the sack or hole for the powder be the third part of a foot broad, and halfe a foot deep, and let the mortar beare in thicknes an inch and a halfe, about one foote high, and the rest onely one inch thicke, the foot shall bee one inch and a halfe thicke, and made square whether the instrument be for the seruice of warres, or recreation, as doth plainely demonstrate the Figure A following. The second mettle is yron, such as commonly Ordnance for ships are made of: and being cast of this stuffe, the rules prescribed shall be found fit, onely let the mettle be somewhat

thicker

thicker in euery place. The third and fourth, and moſt common materialls are paſt-boards and canuas, or paſtboords and chord, and



either of theſe materialls muſt bee ioyned together with glue, and being to bee made of either of theſe materialls there muſt be had a wo-

den foot, with the powder sacke or hole made hollow below in the wood, as is represented by the Figure B. the precedent measures being obserued which is the third part of the diametre, &c.

But if the instrument be to bee made of either of the two first mettalls, that belongs to the Founders office, but of the two last materials euery man at his owne pleasure may compose it of what size he please, and to begin he must haue a wodden rowler of such bigness as he shall desire to make the diametre of his Morter-peece, and vpon that rowler let the pastbords and canuas with good store of glue be rowled: which being done, let them dry a while vpon the rowler, and another while off from the rowler,

rowler, and when this kinde of truncke is very dry, let the woden foot be ioyned to the one end with glue and nailes very fast; and then couer the whole with chord and glue againe; which being well dryed, the instrument may bee of long service, provided that it bee not over-charged; and as for the length, the longest carry furthest, and the thickest dure longest, by the figure C. precedent the instrument is represented perfect, with the touch-hole in the right place required.

CHAP.

Chap. III.

The manner how to make granades or mettle for the morter, or hand.

ALl granads being made to breake, ought to be compoſed of the moſt brickle mettle that may be found, as of braſſe, adding the third part of Tin to it. (as the Founders know right well) they may be alſo made of yron, or of glaſſe to caſt out of mens hands, ſo that the glaſſe bee made very thicke, and theſe will worke wondrous effects, eſpecially in any throng of horſemen or footmen. And as for the thickneſſe of thoſe which are made of braſſe, if the di-

ameter

ameter be one foot, let the mettle be one inch thicke, and let them be somewhat longer then they are round: as doth demonstrate the figure A. leauing at the one end, as it were a handle, and on the other, a screwed hole; by which meanes the granad may be charged, also, let there be made a hollow vice fitting for the former screw, which vice shall be filled with a slow composition made with gunpowder well bruised and culled, and then made into past with oile of petrole: but if the powder be excellent good and strong, then mingle with a pound of powder, one ounce of Charcoale dust, to make it vveaker, then let the composition bee vvell beaten into the hollovv vice, vvhich is represented by the figure B.

And

And the granad shal be filled with fine gun-powder, which being full, let the vice be screwed into the hollow hole of the granade, onely

it is to be noted that the vice must not be open at the lower end, but haue a bottom sodered strongly, wherein shall bee made three or foure

foure little holes about the bignes of a tag of a point to giue fire to the powder when the granad hath flowne the ſpace required. For the performance wherof it is needfull that you know the quickneſſe or ſlowneſſe of the mixture wherwith the hollow ſcrew is to be filled. And for the better experience, it ſhall bee conuenient to make triall of one with a granade made of wood, cloath, paitboord, or any other ſtuffe filled with earth, but let it be neere to the weight of thoſe which you deſire to make vſe of, afterward, and by that meanes you may know how long you ought to make your hollow vices, which are called by their proper tearmes Port-fires, and thus much of your granade being per-

performed, novv let it bee all covered over, vvith either Chord, Canuas, or Paſtboord, and dipped in glue or in pitch; this covering may be neere halfe an inch thicke: to the end that the granade going out of the Morter vvith violence it breake not, and vvorke his execution vpon your ſelfe or your company inſtead of your enemies; of vvhat mettall ſoever the granad is made, theſe rules are to be obſerved, and by the figure C, is repreſented a granade quite finiſhed; and dipped into pitch, by vvhich meanes it may bee conſerved many yeares: theſe ſorts of granads vvorke great effects falling vpon houſes; they caſt downe the vvalles and coverings, likewiſe

wise they vvorke vvonderous operations amongst either horsemen or footmen, tearing both man and beast in pieces, sparing nothing.

CHAP.

CHAP. IV.

The manner how to make Granads of Canuas for the Morter.

THe operation or execution of these sorts of granads made of Canuas is quite contrary to those prescribed: these are onely fit to set a Towne on fire, the houses whereof are most couered with reede, straw, or broome, they are not of so violent execution as the precedent, yet notwithstanding of as great cost, and for the making of them, you must haue a wooden rowler

rowler, which is represented by the figure A, of the bigneſſe you deſire to make the granad (which alwaies ought to be leſſe then the Calliber or bore of your morter, to the end they may bee covered afterward) and vpon the rowler make a ſacke of ſuch cloth as you pleaſe, as doth repreſent the figure B, cutting a piece to couer the vpper end, when the ſacke ſhall be full of the compoſition following. Take foure pound of ſalt-peter, two pound of gunpowder-duſt, two pound of brimſtone, all theſe being well pulveriſed, let them be moyſtened with oyle of petrole, and then fill your ſackes with the ſame, and cover them with chord, which done, pierce the ſacke full of holes with a great bodkin, as repreſenteth the figure E, and in euery

hole, place a little yron barrell charged like a pistoll barrell, these little barrells are represented by D, which must be driuen into the sacke vp to

the head, and the granad being thus disposed, let there be made at the one end a hole about one inch deepe, which shall serue to prime it with pow-

powder-duſt, moyſtened with oyle of petrole, onely it is to be noted that the touch-holes of the little barrells be made ſomewhat large, to the end that the ruſt ſtop them not, being long time kept amongſt the ſalt-peter, and ſo they may be conſerved many yeeres, and ready for ſervice in all occaſions, the figure C. doth demonſtrate the granad perfect and burning.

CHAP. V.

How to make fiery arrowes.

TO avoyde all confusion, I will treat first of all the fires which are cast with violence, and afterward of those which may be cast out of mens hands. And first it is to be observed, that fiery arrowes are of great effects and noysome at sea, specially if the ships approach any thing neere, so that they may bee shot, or cast into the sayles, chording or wood of the ships, either by crosbowes, long bowes, or any other meanes, for so much as a ship being

once

once a fire, hardly can it be extinguished. And thus the arrowes ought to be made: first a long shaft of wood, and ioyned to it an yron head made after the manner of the figure A, and about the middle of that head, make fast a linnen bag in the forme of an oliue, leauing open a hole at the end before, as may be seene by the figure B, that it may bee filled with the composition following. Take one pound of Saltpeter, halfe a pound of gunpowder-dust, and halfe a pound of brimstone in povvder: all these ingredients beeing well mingled, and mingled with oyle of petrole, then fill the bagge round about the arrow head, noted by B, and then let all be well bound about with wyre. And for the priming of these arrowes, dip

cotten weeke into gunpowder, wet with water, but let the cotton be wel dried again before it be applied to the arrow head. Now for the ioyning

of your arrow head, to the wodden shaft it ought to be so slightly fastned to it, that being shooke into any sayle, cordage, or wood, so that if any

ny one would plucke it backe, the shaft should slip out of the head, and so continue burning in the place pretended, and to hinder that one may not pluck out the head with their hands, there may be made a small hole quite through backeward, and so the fire will hinder a man from touching any part thereof, although it should sticke in other of his fellowes clothes. There may be made little arrows of the same fashion, to be cast out of mens hands in any meetings, assaults, breaches, or other occasions; and if there shall be great hast for the making of them, lesse fashion may serue, hauing onely little stickes of wood, about a foote and a halfe long, and in stead of the head prescribed, a pyke (like a great nayle) and in lieu of feathers,

pieces of past-boord, stucke into the ends of the wood being slit, but the former composition shall be required.

CHAP. VI.

How the granads are to be charged into the morter.

ALthough it seeme to be but a small difficulty to charge the granads into the morter, yet it is the greatest mastery and most curious worke which hath beene found amongst fireworks, and the most industrious Engi-

Enginers that ever I yet saw, haue after beene deceived therein, and shot out their granads, they not taking fire, which is absolutely one of the greatest faults that may be committed. Then to avoyde such great errors it shall be needfull to note many obseruations following, whereof the first is that you put not too much powder in your morter, marmarked A, but onely the powder-sacke full; secondly, that the priming of your granad be firme, not spoyled with dust or dyrtie moistnes, or other like thing, that it bee not also too dry, least all breake about your selfe going out of the Morter taking fire too quicke, which all fire-works are very subiect to doe, then take heed that the granad enter not too hardly into the morter, which will

cause

cause it to breake in the discharging, also it is not needful that it enter too loosely. All these things being well obserued, you must haue alwaies rea-

dy port-fires for your morter, which may be made about the bigneſſe of your litle finger, and hollowed within about the bignes of a quill, euen

to

to the bottome, noted B, this port-fire is to enter with a vice into the touch-hole of the morter, about half an inch, and to turne the vice without any key: there may be made 4, buttons at the out-side of the vpper end, and let this portfire be charged with a slow composition, mingling 4. ounces of charcoale with a pound of powder-dust, this being done, and your granad placed in your morter, so that it shake not, close vp the chinks round about your granade, within the morter, with grease, waxe, pitch & grease, or any such like thing you may so cover the granad with some such stuffe, that in any weather wet or dry, you shal find no difficulty to shoote off the granad in any place whereseoever you please.

CHAP.

Chap. VII.

The manner how to ſhoot the granads.

Here is no leſſe difficultie well to diſcharge the granads then to charge them, but the contrary will eaſily appeare, for it is there where the hazards and dangers moſt great, doe meet together. And the firſt of all are the aduerſaries Canons from whoſe dangers the Enginier ſhall eaſily conſerue himſelfe, as followeth, cauſing to be made a trench like vnto an halfe moone, the connexity thereof being towards the enemy

nemy, as appeareth by the figure A, this trench ſhall be of ſuch bigneſſe as the Enginier may conueniently place all ſuch things as ſhall be needfull for his preſent vſe. The ſecond difficulty following, is how to ſhoot them right to the places of any Fort or Towne deſired, being not poſſible to ſee the places to take leuel at them without eminent danger of their Canon and musket-ſhot: which difficultie ſhall be thus auoyded, and yet leuel right, and ſend the granads to the places required: let there bee be two ſtaues ſet vpright, betweene the Towne, Fort, or Cittadell and the Trench, the one of theſe ſtaues ſhal be ſomewhat long, the other may be ſhort, and that, planted vpon the brim of the trench; but the longeſt ſomewhat diſtant in a right line towards

wards the place pretended, as doth demonstrate the figures BC, these staues shall be so disposed that you may see the extremities of each, be-

ing in the trench out of the enemies sight, and by the sight of these two extremities, you may direct your granads at your pleasure inclining your

[morter-

morter-piece vpon either side, as shal be needfull without danger of the enemie, having onelie knowne the distance betwixt the trench and the towne, or place of the towne which you shal desire to destroy. The third and last difficultie is to know the true length or distance that your morter doth beare, of which to be certaine, you must trie it before, shooting granads of the same weight, & with one sort of powder, and with a leuel, take divers sorts of elevations, & so may you know such an elevation doth carie so far, and such carie so far with such powder such a weight, being charged, the maner of taking these elevations is represented by the figure D, & the level in a bigger volume by the figure E, this leuel being placed vpon the mouth of the morter piece, and vn-

vnder the foot thereof: wedges, you may giue to the morter what incli nation shall be required: and to be sure from all harme of your own granads, which by chance may break goingout of the Morter-piece, let there be made in the trench a little corner hollow into, or behind the which you may alwayes retyre, having given fire to the Morter. It shall be also needful that some one watch where the granad doth fall whether too short or too farre; that you may the better direct the next shot: this method is to bee obserued in shooting all sorts of granads, stones, or other like things.

CHAP

CHAP. VIII.

A most violent method to set a Towne on fire.

HItherto there hath not been found any means or inuention more certaine or violent, whereby one might convey fire for the destruction of the enemies habitations then by the helpe of the precedent grands, which very hardly cause any disorder or combustion, vnlesse amongst houses covered with straw, whereof few are to bee found in goodly townes. And therefore I will here prescribe a new way

much different from the others be-
fore written; against which hardly
or not at all may be made any resi-
stance or possibilitie for defence, the
violence, rage, and order being of
such a fearfull power and execution,
prouided that the Enginier doe but
meanly effect his purpose & designe,
and for the practise hereof, let there
be made a kind of well in the ground
but sloping, as doth demonstrate
the figure A, of such deepenesse as
shall be thought fit, but it is to be
noted, that the neerer you are to the
towne, the lesser slooping will be
best, and most easie for the perfor-
mance. The hollow pit or well be-
ing made, let there be placed in the
bottome thereof one or two barrell
of gunpowder, as shall be seen need
full, according to the proximite o
di

distance betweene the place and towne, & these barrels may be places very conueniently placed with good store of straw about them to keepe

them from the moystures of the earth. And in one, or else in both, you shall place a gunlocke, making fast to the clicket thereof a chaine of

sufficient length to reach out of the hole vpon the plaine ground, but this chaine shall be curiously lodged in a small gutter, which afterward shall be covered with earth, to the end that the fire doe not ouer-heate it, then cover the barrells of powder with strong woodden planckes, or broade stones, covering them againe with earth, and then lay good store of fresh straw and bauins, and fagots and in the midst of these let there be placed a great fagot, made of peeces of timber, of a reasonable length, being well bound together with chains of yron in three or foure places, as doth appeare by the figure B, and then set fire on the straw, wood, and all that shall be in the pit, giving the great wood time to kindle, and this great fagot being in a

great

great arder, let the chaines be drawn which are tyed to the latches of the gunne lockes, and doubtlesse you shall see braue sports; and if there be many pieces of Ordnance about the towne or place thus besiedged, let them be all disposed ready to shoote where this great fagot fals, and whosoeuer would hut this inuention in practise, ought to make many of these paits about a towne, giuing fire to them all at once: but the Inginier to know iustly how far these great flaming fagots may flye, the hollow pit declining so many degrees, hee ought to make tryall before in some large place, where he may haue room for his experience: now resteth only to explicate how a man may giue fire to the stuv in the pit without danger, for so much that euery man

would not least all should take fire together. Then to be free from this perill, it may be fired by a traine of powder, by a Gunlocke, a piece of match, a candles end, or other like inuention: Peradventure, you may thinke that there may be danger in drawing the chaine when all is on fire; to which I answer these may be ioyned to it, a chord of such length as shall seeme necessarie; The Engineer who shall put this in practise, may adde of his inuention what hee thinkes fit, *Facilius est enim addere inuento quam invenire.*

CHAP. IX.

How to make Granads to cast with mens hands.

HAving taught how to make Granads for the Morter, which by the violence of that most wonderfull instrument may be transported very farre over waters, walls, or bulwarks, working strange and rude executions or effects, I will now shew how it shall bee easie to make two or three sorts of Granads to bee cast out of mens hands, the effects whereof are no lesse to bee esteemed then the other, chiefly in assaults,

whether it be for the offendants or defendants. The chiefest and of greatest operation is made of any kind of brickle mettle as the precedents; and their fabrication is not much different from the other, onely more rounder and lesser, and the single ones having a long neck to seem for the Port fire, as doth appeare by the figure A, and first of all the granad is to be filled with fine gunpowder, and afterward fill the neck with a slow composition as followeth. Take 1. pound of gunpowder dust, two ounces of charcoale dust three ounces of saltpeter, all these well mingled together, fill the portfire required, but this mixture must be well beaten into the port-fire, and the granads being thus finished, they may be kept a yeare, ten yeares, yea twenty

ty if need be. It is to be noted that these granads must not be freed vntill a man is ready to cast them away even in the same instant, be-

cause the port-fire being consumed, the granad breaks in divers pieces, and each piece sufficient to kill eyther man or beast, and therefore the hand-

handling of them is somewhat dangerous. The second manner of Granad to bee cast out of the hand, is made also of brickle mettle, but hath no necke for a Portfire, but is onelie round, hauing in one side a hole as appears by the figure B, and at this hole it is to be filled with drie powder, and then is to bee put into this hole to stop it, cotten wicke made as followeth. Take good Gunpowder and steepe it in faire water, and being dissolved, take the cotten wicke and steep it in the Gunpowder dissolued, which done, hang it out to drie; but let it be doubled eight or ten times, to the end that it may the better receiue the powder, and being drie, cut it in such pieces as you shal need, putting the one end into the Granad at the hole, and then put that Granad

into

nto another pot a little bigger then
he Granad, as appeareth by the fi-
gure C, ſo that you may put a little
drie powder round about the leſſer
Granad betweene the pots and Gra-
nad, then cover the mouth of the
laſt earthen pot either with leather
or ſuch like ſtuffe, and bind it round
about with wyre, but firſt put the
wire through pieces of match about
halfe a foot of length as may appear
by D, and when you deſire to make
vſe of this ſort of granad, ſet on fire
euery end of theſe pieces of match,
and caſt the pot away, which fal-
ling either vpon the ground, or anie
ſouldiers Armour, you ſhall ſee the
earth-pot breake, the Granad ſplit,
and worke ſuch furious effects,
eyther at a breach or anie approch.
The third ſort of Granad is made
much

much like to either of those precedent, except onely it may bee made double or single, of glasse or of earth onely shall be needfull to be made very thicke and if it be to be made single, the portfire ought to be either of wood or of pastboord, and well glued in, and this last sort may worke great effects. Now having somwhat largely treated of the morter, granads, and of their vse, I will speake a little of other oyly fireworkes very pernicious and noysome to all assailants.

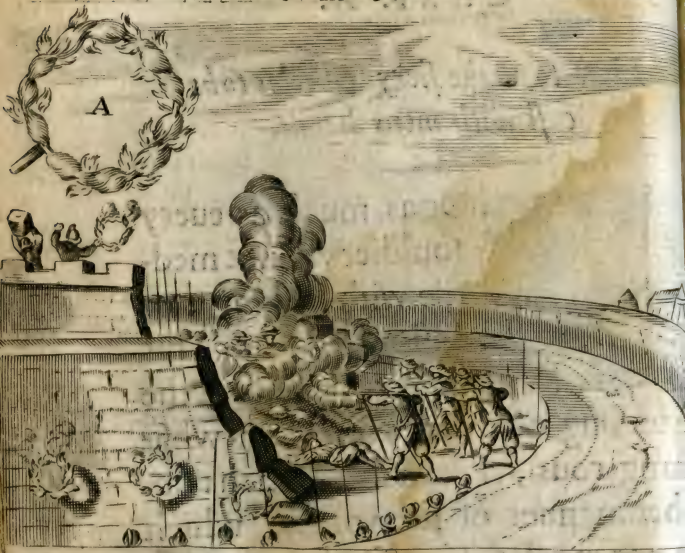
CHAP.

CHAP. X.

How to make fiery wheeles to be caſt with mens hands.

FOr as much as euery ſouldier wil not meddle with making nor caſting out of his hands granads, the handling of them being ſomewhat dangerous, I will here teach another manner of fireworkes, which is not much leſſe offenſiue, which being well compounded and compacted, and for the making thereof, theſe are more ingredients required, then for the precedents, and is more diffi-

difficultie in making of them as fol-
loweth, Take foure pound of gun-
powder in dust, one pound of char-
coale dust, two pound of tarre, two



pound of salt-peter, and one pound
of Rosin. All these ingredients be-
ing well mingled and heat ouer the
fire, steepe tow or flaxe in the same,

and

ano then wrap the tow or flax about a whope, which is represented by A, and then cover all this againe with Gunpowder dust, & in time of need giue fire to them, and cast them amongst your enemies; onelie is to be obserued that the whops or circles ought not to be to large, but falling vpon a many of souldiers they may there stay and sticke, and to make them more troublesome and intangling, two may be tied a crosse on another, and then falling vpon anie man, he cannot choose but be much astonished with such a fearefull element, and put his company in great disorder.

CHAP.

Chap. XI.

How to make a Shippe of wilde Fire.

AFter a sufficient discourse of all manner of Granads, fierie arrowes and burning wheeles, I cannot thinke it extravagant or amisse, to lay open to the industrious or curious, a method how to make a fiery ship at sea, which shall not begin to burne till it hit against some other vessell, rocke, or such like obstacle, or be hooked or grapled on the inside to be drawne a shore. Hee that will

will vndertake to build one of theſe muſt ſpare no reaſonable coſt to put his intentions or deſignes in execution, and firſt of all muſt be had one ſhip or many, according to the times and occaſions wherein they ſhall be required; and within the ſhippe ſhall bee diſpoſed great ſtore of broken Canons well charged with bullets, and from one Canon to another ſhall be ioyned a port-fire, ſo that the firſt having taken fire, all the reſt muſt needs doe the ſame; theſe Canons ſhall haue their mouthes put out of the Gun-ports ready to bee diſcharged; this done, let there bee good ſtore of dry ſtraw, ſmall dry wood, and tow and flaxe ſteeped in pitch, turpentine, roſine, and tarre; mingle and wrap the tow thus ſteeped, about and amongſt the

wood and straw, and place it betweene all the Canons; the straw and small wood shall be so disposed, that it may take fire when the best part of the Canons are discharged, and the peece of Canon which is to giue fire to the straw, shall be set with the mouth vpward to blow part of the decke away, and at the same time giue fire to great store of granads of all sorts, to adde musket-barrells to barrells of Gunpowder ranged in order aboue the deck, to blow out these things by order, now one, then another by the helpe of slow portfires, but the beginning of this sport ought to be very violent and furious, to frighten and also teare in pieces the enemies at once, & that the rage hereof be the more furious, let the greatest part of the Canons

shoot

ſhoot off thick one after another euen with the water, and at the ſame time the Granads ſhall flye the one farre off, the others fall neere, now a barrell of gunpowder blowes out a part of the flaming ſhip here, and anon another barrell caſte out a quarter of the veſſell ardent there, caſting diuers ſorts of fire here and there as bals, arrowes, granads, double and ſingle ones, made of the compoſition preſcribed in the 5. and 10. chapters, but to hinder all the barrells of powder from taking fire together, which is no ſmall difficultie, euery barrell ought to be plaſtered over, and then covered with glue and a ſiere-cloth, and then put into another barrell; but to make them take fire euery one at your pleaſure, put a Portfire vnto thē, of ſuch length, & ſlow

composition, as you shall thinke fitting. Now to begin this mad sport, fasten three or foure good strong gunlockes within the ship, at one end

within the

of the traine, which is to giue fire to the first Canon, and to every clicket or tackit of the locks, fasten an yron rod, and let the other end of the I-

of the

ron

ron rod passe through the ship, and bee made fast to peeces of strong wood, in the manner of a gyrdle on the outside of the ship, which is represented in the figure by the points; so that touched vpon the outside any thing rudely, the locks must needs strike fire, and set going all the rest; and to make it give fire being hooked in the inside, to draw it ashore, or out of the way, let there be made fast to each clicket of the locks, long wyers, and the other ends of the wyres may be fastned to pieces of wood in the inside of the ship, round about the edge, so that the first thing that shall touch it, sets all going as vpon the outside, but the pieces of wood vpon the outside ought to be very neere the water, as doth demonstrate the figure with the points, and

to conduct this ship as neere to the place as may bee, without danger, there may be fast ioiud to the stern a piece of timber noted A,B, to the end whereof may bee fastned two long ropes, and to them two little boats, in which men shall be for the conducting therof. This here is but a spark of inuention, to which the industrious Enginier shall adde of his what he please, and take this but for an entry of such workes; for although I haue here set downe gunlockes; to giue fire to the Canons, my meaning is that they bee made like gunlocks, but ten times stronger, and harder in going off, leauing to the iudgement of the discreet Enginier, the true disposition of his owne designes.

CHAP.

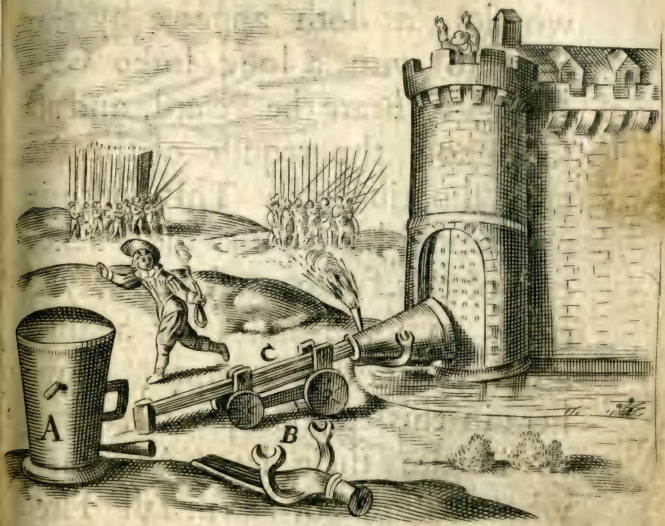
Chap. XII.

How to make a Petard.

Diego *Vfan*, a Spaniard, *Francis Tibourele* a Loreine, and Maſter *Robert Norton* an Engliſh man, hauing al written of fireworks, and neither of them all vnderſtanding how to charge a ſimple Petard, I thought fit to end theſe fireworkes for wars by the deſcription of the ſame, that being of great violence to make entries & breaches into towns caſtles, or houſes, the morter preſcribed, may ſerue to petard a place

as hath beene sayd already: but whosoeuer would make exactly a Petard, ought to cast a Morter much like vnto an Apothecaries morter, as doth represent the figure A, obseruing the rules following, if you make it, to weigh sixe pound of mettle, let the calliber or bore be of such bignesse to containe one pound of powder, or one pound and a halfe: if you adde or diminish more or lesse mettle, augment or diminish the calliber likewise, to hold the fourth part of powder which the mettle doth weigh; and for the charging of the Petard, fill it only with the best gunpowder you can, almost to the brim, and then couer it with a round bord made fit for the purpose, leauing aside all frivolous directions, written by others aforenamed; and for the priming

priming of the Petard, make a port-fire of ſlow compoſition, as for the precedent fireworkes of what length you pleaſe; and to breake open the



place you deſire if it bee acceſſible, then with the heele or breach of the Petard vpon the ground or ſome great ſtone or piece of wood, and the mouth

mouth against the part of the dore, gate, or elsewhere, which you shall iudge fittest, but if the place bee vnaccessible, then make a kinde of a little Cart with two or foure wheeles, as doth appeare by the figure B, with a long forke very strong to beare the Petard, and also support the requile of the Petard shooting off: This forke is represented by C, but the backer end of this forke must bee stayed either in some hole, or against a stake, or other meanes; Now here in this treatie not intending to imitate these late Authours, who writing of artificiall Fireworkes; have prescribed natures and compositions of almost all manner of drugges, the meanes whereof

whereof may bee found in anie Apothecaryes ſhopppe, doubtleſſe eyther to perſwade the curious Readers that they had profound knowledge, many rare ſecrets, or elſe the better to hide their ignorance, by that great confuſion and expence, whereunto few or none would extend and vſe their purſes to make proofe and experience of. I will finiſh this treatie of artificiall Fire-workes for Warres, and goe forward to the ſecond treatie of Fire-workes for pleaſure and recreation, and explaine in the Preface apologitike, for what vſe all theſe vnknowne dregges are fit for, which ſeemes to thoſe that are ignorant of ſuch rare and wonderfull effects. As

Selar-

Salarmoniake, Antemonie, Arse-
neeke, Vitrioll, Stonelime, Thutie,
Adamant stone, not forgetting quick
siluer.

THE

THE SECOND TREATISE OF ARtificiall Fire-workes for pleasure.

Chap. I.

Erspicuous & plain shall be the method to make all manner of Fire-workes for pleasure, (which heare I will set downe for the contentment of all curious and ingenious Artists) without such a number of vnknowne dregges for mixtures, as many hereto-

fore

tofore haue prescribed more fittest for some prodigious actions, then to mingle for artificiall fireworkes; and principally for those which are inuented for pleasure, for these haue no need of venemous smoaks to poison the spectatours, making mirth turne to mischiefe (which notwithstanding cannot be done in an open ayre) neither haue they need of such a continuing, ardent and violent flame, as to consume Cities or habitations, but onely of a gentle and pleasing flame to the eyes of the spectactors; and thus they are divided into three sorts; The first are those which ascend and mount into the ayre, The second are such as consume vpon the earth; The third and last sort, are those which swim and burne in the water. Those which

worke

worke their effects in the ayre, are likewise divided into three sorts, the chiefest and most noble of all are the ballouns; The second the rockets; and the third are flying saucissouns, those which stand fixt vpon the ground are also distinguished into three sorts; The first are the rockets for the ground, the second the fierie lances and the third saucissouns: The fires for the water, may haue their triple diuision; globes or balls make the first, double rockets; the second, and single ones the last; and to treate of euery one in particular, I wil begin with the rockets for the ayre; and first of all describe their moulds, and the measures which must be obserued in making of them.

CHAP.

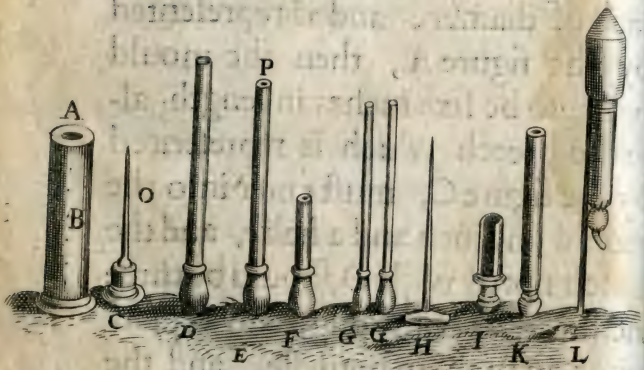
Chap. II.

A method to make moulds for rockets for the Ayre.

ALthough that ballouns are absolutely the most noble sort of fireworkes, yet for so much as all great fireworkes are composed rather of rockets, then of ballouns, I thinke it conuenient, to begin this second treatise with these: first of all making the description of their moulds, which may bee made either of brasse or wood, the one being as good as the other for vse, if the measures following be obserued; which shall

ſhall be conuenient for all ſorts of bigneſſes, becauſe they depend onely vpon the calliber or bore, and that being enlarged, the other parts will be all enlarged alſo, that being diminiſhed, all the reſt will be diminiſhed likewiſe. Then to make a mould, the calliber whereof ſhall be ſuppoſed an inch of diamer, and is repreſented by the figure A, then the mould ought to be ſixe inches in length; alſo the breech which is repreſented by the figure C, muſt enter into the mould one inch and a halfe, and the broch noted with O, ſhould be three inches and a halfe long, and a quarter of an inch in bigneſſe, and the rowler D, which is to rowle the chartouſh or coffins of paper vpon, ſhall be three quarters of an inch in bigneſſe, & the rammer E, to charge

andram the rocket, shall be some-what lesse then the rowler, to the end that it may enter easily into the car-touch or coffins.



Also it shall be made hollow, as deepe as the broch is long, as doth appeare at P, because the rocket must be loaded, the broch being in it, as

for

for the massif marked with F, shal be of the same bigneſſe as the charger. The 2. other rowlers noted G, G, or to make serpents, as shall be instructed hereafter, and the bodkin H, is to make holes through your starres, as shall follow, the Lanterne I, is proper to charge the compoſition into the rockets. The figure noted K, is the cartoush or coffin ready to bee charged, and by the figure L, is represented a rocket quite made. This method prescribed may be obserued in all sorts of moulds, for if you would make one lesser, as of halfe an inch, the calliber or bore, then the length must be 3. inches, which is 6. halfe inches, the breech shall enter 3. quarters of an inch, the broch shall be an inch 3. quarters long, & the rowler for the cartoush shall be half a quar-

of an inch; but if you make the caliber of two inches of diameter, let the mould be 12. inches in length, the breech shall be 3 inches, and the broch 7 inches of length; and so for all the other parts appertaining to the mould. Now followes the description and manner how to make a rocket.

CHAP.

Chap. III.

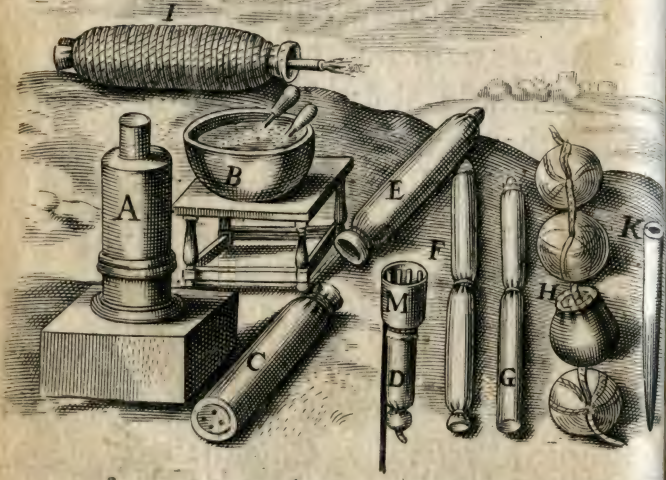
How to make a flying rocket for the Ayre.

FOr to make the mixture or compoſition of all middle-ſized rockets, take a pound of gunpowder finely bruiſed and boulted with two ounces of charcoale-duſt, mingle theſe well together, and try one rocket, which if it breake, adde more charcoale duſt to the compoſition; but if the rocket doe not aſcend, beeing weak, adde more powder duſt boulted as before ſaid; and ſo ſhall you

make your compoſition ſtronger or weaker according to your deſire; inſtead of charcoale, you may put ſea-coale, ſaw-duſt, or any other like thing, ſo that you keepe a Medium, not putting too much nor too little; which thus you ſhall know if the rocket mount not, you haue added too much coleduſt; but if it breake, you haue not put coleduſt enough; for the charcole-duſt which you put into the powder duſt, is onely to moderate the violence of the powder; and to make the rockets tayle appear more beautifull; which ſea-coale doth as well as charchoale, and to charge the rocket with this compoſition as it ought tobe many rules are required or to be obſerued; and 1. of al that in charging the rocket, you put not too much cõpoſition at once in the cartouſh or coffin; 2., that it

be beaten with a mallet 3. or 4. good ſtrokes; and then put new compoſition thereupon, beating it again with blowes as before; and thus putting in at ſeuerall times the quantity of one or two ſpoonefulls, at each time beating it well with a mallet, and let not the cartouſh bee filled higher then the mould, but being iuſt full thereto, then double downe halfe of the paper with the bodkin beating it (as the compoſition before) & at laſt pierce 2. or 3. holes with the ſame bodkin to the powder to giue fire, to either ſtars, ſerpents, or ſauceſſous, as ſhall be taught following; and theſe holes are repreſēted by C, let the reſt of the cartouſh be cut even with the mould, and thus muſt be made all ſorts of rockets, great or little ones. It is to be noted, that the compoſition preſcribed is fit; for all ſorts of

rockets, great or little, but onely it must be made weaker for great ones then for little ones, adding more charcoale to it, for the whole secret is



in making the composition neither to strong, nor to weake, and not as al writers hitherto haue thought, following each one the others errors, thin-

thinking that the true manner of making excellent rockets, is to put many ingredients into their compositions, wherein they haue all erred absurdly; and last of all Master *Norton*, for absolutely the best composition is, that which is made of fewest ingredients; and the rockets made thereof may be kept many yeares, and good at all times.

CHAP.

Chap. IV.

How to make moulds for Rockets for the ground.

THe mould muſt bee o-therwiſe made then the precedent, becauſe ſuch violence is not required in theſe, as in thoſe which mount into the ayre, but onely of ſomewhat longer continuance; and therefore theſe meaſures following ſhall ſerve at all times, neuer being made bigger nor leſſer, but alwaies the ſame for all occaſions. Let the calliber behalf an inch, the diameter, and 5. or 6. inches of length, and the rowler for the cartouſh

touſh ſhall be foure lines in diameter which is the third part of an inch, and the rowler to charge withall ſomewhat leſſer to enter without ſpoyling the cartouſh: next let not the broch be longer then 3. quarters of an inch, and the breech ſhall enter halfe an inch into the mould; and the cauſe of this great alteration is, that the rockets which mount into the aire, haue need of great and violent ſtrength, and by conſequence laſt not long, but wee deſire that thoſe vpon the ground may dure a long while, with a gentle motion, which ſhall be eaſily performed, the rules following being obſerued.

CHAP.

Chap. V.

How to make the compoſition for rocket upon the ground.

THis is the eaſieſt compoſition of all others, for in this ſhall be nothing required, but onely Gunpowder well beaten and boulted, ſo that it be as fine as flower, and then fill your rockets by little and little well beating it into the cartouſhes or coffins with a mallet, as the rockets for the ayre, and being full within an inch of the brim of the mould, double downe one quarter of the paper, or cartouſh, beating or preſſing it with

3. or

3. or 4. good ſtrokes of the mallet, and then with your bodkin, pierce a hole to the compoſition; which done; put into the cartouſh about the charge of a Piſtol, of good gunpowder, and then double down the one halfe of the cartouſh, giuing a gentle blow or two with the mallet, &with a ſmal cord, or big line, choke the reſt, and what ſhall reſt aboue the choaking, cut it off, leauing a piked point, as appeareth by the figure E, in the 3. chapter of this Treatiſe; and your rocket being thus finiſhed, and primed with a little wet powder, and layd a drying, ſhall be ready for all occaſions.

CHAP.

Chap. VI.

The manner how to make Serpents.

THe Serpents are to bee made eyther of the compoſition for rockets on the ground, or of that for the ayre, for being filled with the compoſition fitting for the grouund; they will ſpreade and ſparkle liuely in the ayre, but if filled with the other compoſition, they will fall weaving neerer together; notwithſtanding

ſtanding eyther ſort will ſhew diuers pleaſing actions in the ayre, being made as followeth. Let the cartouſh be about foure inches long and rowled vpon a rowler, ſomewhat bigger then a gooſe quill, as is repreſented by the precedent figure G, in the third chapter, the paper ought to goe about the rowler nine or ten times, and then choaked almoſt in the middle, yet leaving a little hole to ſee through, and the longeſt part ſhall be filled with the compoſition, but the ſhorter with fine grayned powder, and choaked cloſe; alſo the longeſt end muſt bee halfe choaked cloſe, as doth appeare by the figure F, chapter third but if you deſire not to haue them wamble in the ayre, then let them not bee choaked after the compoſition

position, but as doth represent the figure G, both which figures, F, G, represent Serpents quite finished.

CHAP

Chap. VII.

How to make golden rayne.

Many there are (ſpecially in France) who make rockets, yea and boaſt that they are perfect therein, who know not what golden raine is, but thinke it to be ſome other thing then it is; wherefore to put them out of doubt, and to teach all others who deſire the knowledge thereof, I will here ſet downe the deſcription and maner how to make it. Take gooſe quils, and cut off the hollow ends, leaving them as long as may be, as the figure K, doth demonſtrate third

chap. and fill these quils with the composition of rockets for the ayre, at the last stopping euery one with a little wet powder to keepe in the dry powder, & crowning a rocket with these (as shall be taught following chap 12. in its true place) will shew a most glorious & pleasing raine, w some hauing in times past seen, haue called it golden rayne for the beauty thereof, but of later times it is more commonly called golden hear: many beautifull and strange figures may be represented in the ayre, with this ma ner of rayne, as shall follow in the 1 chap. treating how to represent ma ny sorts of figures in the ayre with rockets.

CHA

CHAP. VIII.

The manner how to make Starres.

ALthough that there bee many sorts of compositions for starres, yet I will set downe here but two of the best; all the rest being nothing worth, but friuolous and expensiue: the first and best sort, is to be made of dry powder, and the other of moystened powder as followeth. For the 1. sort take 1. pound of saltpeter, halfe a pound of brimston, and a quarter of a pound of gunpowderdust, al these being pluerised & mingled together,

wrap the quantity of a nutmeg in tow in a linnen rag, or in paper, and bind it fast, as appeareth by the precedent figure H, chap 3. and to prime them, you must pierce them with the bodkin, and put stoupell or cotten wieke dipt in powder through them (which shall be made as followeth in the 11. chap.) and to make the second sort, take 1. pound of saltpeter, and halfe a pound of powder-dust, and halfe a pound of brimstone all these wel pulverised and mingled together, moysten them with eyther oyle of petrole, or els with fair water onely, to make a past of them, whereof make little balls about the bignes of a musket bullet, and whilest they are moist, rowle them in dry powder dust, then let them dry, and then may you employ them at your pleasure, with-

without further trouble; for the laſt powder in which they are rouled, doth ſerue for their priming. This laſt ſort of ſtarres doth not make ſo beautifull a ſhew in the ayre as the others, for falling downe, the flame of them takes the forme of a lampe, hauing no force to expel it like wings as the others doe, for the flame of the others blowing out of the two ſides pierced, make it ſtretch in length, and by that meanes ſhew greater in the ayre.

Potas: Nitrat: ℥ij
Sulphur Lotum ℥ij
Gunpowder ℥j
M. in aq: Pur: et Sac: purif:
q.s ut f massa
Stet dust a little if you
wish and roll when moist
in powder dust.

Chap. IX.

How to make Starres giuing great Reports.

TO make Starres, that each one ſhall giue a report like a Piſtoll or bigger gunne, you muſt firſt make little ſauciſſons (as I taught in the chapter following, but the ſauciſſon need not to bee couered with chord) and being made and pierced, take as much of the former dry compoſition, and bind it to the end of the ſauciſſon which is pierced, making a hole through the compoſition, and paſſe a piece of ſtoupell or cotten-

wicke

wieke as in the other ſtarres; but if you take of the moyſt compoſition, you may onely leaue the paper hollow at the end of the ſauciſſon, fitting to contain the quantity of compoſition required, putting a little grained powder before, and prime theſe ſtarres as the others, of the ſame compoſition; theſe ſtarres are very troubleſome and little in vſe, becauſe that a great rocket can carry but few vp into the ayre, and by conſequence worke but a ſmall effect, and moreouer they are very long in making. One may make Starres in the ſame manner, which ending, turne to ſerpents and others as ſhall pleaſe the workeman.

CHAP

Chap. X.

The manner how to make Sauciſſons.

IN this chapter, my intention is not to treate of the ſauciſſon which flyes into the ayre, but only of that which ſtands firme in great workes, or elſe which is applyed to rockets, which thus is made as followeth; you muſt haue a rowler of ſuch bignes as you deſire to haue the concauity of your ſauciſſon, wherupon rowle as much paper as you pleaſe, and then choake

it

it at the one end; which done, fill it with grayned powder,& choake the other end alſo, and cover all the ſauciſſon from the one end to the other, with ſmall chord, as doth repreſent the figure I. chap. 7. and glue that cord with ſtrong glue all ouer, and when you would make vſe of theſe ſauciſſons, pierce them at the end with your bodkin, and put into the hole a quill filled with fine powder duſt, which ſhall ſerue for a portfire, and the other end of the quill ſhall paſſe through a board, whereupon you meane to faſten them, and ſhall enter into a portfire in the other ſide of the wood, which ſhall be faſtned all along the wood, and ſo may you faſten what ſtore you pleaſe neere together, or farre aſunder, this quill is repreſented by the figure L, and

by

by this meanes one end of the port fire beginning; all the whole rank of sauciſſons will giue their report one after the other. But if your sauciſſon is to be applied to a rocket, it shall onely be pierced at one end, and primed with a little grained powder and faſten it to the top of the rocket either with paper, parchment, or any thing elſe, ſo that the rocket, ending the sauciſſō, may take fire; ſo shal you not faile of your intent or deſigne.

CHAP

Chap. 11.

How to make Stoupel or preparing of your Cotten wieke.

TO make Stoupell, not the meaneſt, but the beſt that may be made to giue fire (which in proper tearme is called eſtoupelling) to all manner of fire-workes. Take Cotten-wieke, and double it as oft as ſhall bee needfull for your vſe, as if it were to eſtoupel your fiery lances; then double it eight or ten times, and alſo for the ſtoupeling of great

great rockets ; but if it bee to passe through your starres, then 4. or 5. threds shall suffice; so hauing doubled your cotten wieke fitting for your purpose, steepe it in faire water, and then wring it betweene your hands, and take gunpowder dust, without other mixture, and steepe it in faire water, not putting too much water, nor too little, but onely till it appear like durt, and then put into it your cotten wieke, and there turning and winding it till it hath sufficiently taken powder in euery place and parcell, then draw it out, putting a little dry dust vpon it, & hang it a drying in the sunne or els-where, and that being dry, you shall haue the most excellent stoppel that may bee made for your vse at al times, leaving aside all such ingredients which ignorants

esteeme

esteeme so highly of, as Aqua-vitæ, white wine, strong lee, quick-lime, vineger, vrine, and diuers others, for which I would not lose so much time time as to repeat them, but now goe forward, and shew how to ioyne all the parts of a rocket.

CHAP.

Chap. XII.

The manner how to assemble and set together the parts of a rocket.

When the rocket is finished and taken out of the mould noted A, in the figure of the 3 chapter, and the rocket is noted with the letter C in the same figure, then must you ioyne to the end of the rocket, which is not choaked an empty cartoush or coffin, much bigger then the rocket is large, which is represented by M in the same figure, in this cartoush you shall put your serpents, golden rayne, starres, sauciſſons, or other things at your pleasure, but first of all you

you must put in the bottome powder dust; onelie enough to couer the bottome of the large cartoush; and then put the serpents with the ends downeward which are to take fire; and likewise the golden rayne in the same manner, but it is the custome to put a little powder dust amongst the stars; this cartoush being thus filled, couer it with a single piece of paper, and afterward paste vpon that a picked cap made also of single paper, and to make perfect your rocket you must binde a rod of such length and waight, that being bound to the rocket, it must weigh down the rocket on your finger being neere* to the rocket, and then stoupel your rocket, that is to say, prime it with cotten-wicke, and it is thus finished either to fire or keepe.

*about the length of the rocket from its muzzle

This

This method is fit for all sorts of rockets, great ones or little ones, except that little ones must haue the vpper cartoush no bigger then the rocket, onely to hold halfe a dozen of starres or serpents, or one saucisson for so much as many beeing fired together, great confusion would happen, if great rockets should bee put together, and not prepared otherwise.

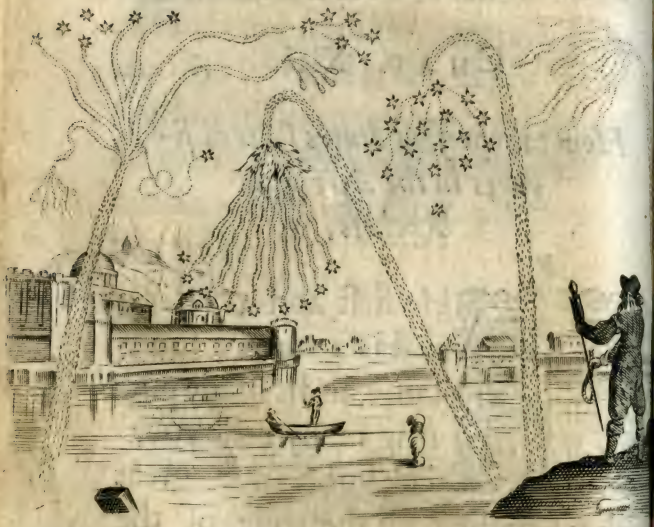
CHAP.

CHAP. XIII.

How to represent diuers sorts of figures in the Ayre with Rockets.

THe first and most rarest is a tree or fountaine, and is made putting many little rockets vpon one great rocket, passing all the rodes of the little ones through the large cartoush of the great rocket, and if the little rockets take fire while the great one is mounting vp, they will represent

a tree: but if they take fire when the great rocket is turning downe againe towards the ground, then they will bee like to a fountaine



of fire, and if there bee two or three little rockets hauing no rods amongst others they will make divers motions contrarie to the rest most

moſt pleaſing. The ſecond figure is the golden rayne; and that is made when manie quils filled (as aforeſaid) are put vpon a great rocket; for certainelie all thoſe quills taking fire will ſeeme like a great ſhower of fierie rayne to thoſe who are vnder it, but to thoſe who are a ſide of, like beautifull long haire. The third figure are Starres, which are repreſented putting onelie manie Starres vpon a great rocket. The fourth are ſerpents which are alreadie deſcribed, but to make all theſe preſcribed figures varie, you may tye manie little ones together by the ends, which take not fire, the quils, or ſerpents may bee tyed in like manner; but the thread wherewithall they are tyed, muſt be at leaſt two or three inches

long, betwixt each one, and you shall see diuers sorts of figures in the ayre, changing themselues into much varietie.

CHAP.

Chap. XIV.

How to make fierie boxes.

THe fire-boxes are made of many rockets being put into a large cartoush the bottome whereof is couered with powder duſt, and pierced in the middle to paſſe through a port fire or ſtoupell, to giue fire to the rockets within the cartoush or coffin, which flying out, leaue the cartoush moſt commonly whole and vncracked, thoſe boxes are onely to be couered with a peece of paper, that the rockets taking fire may flie out

without resistance; and the reason why they are to bee couered, is because if manie be made one neere to another, they should not take fire all at once.

CHAP

CHAP. XV.

How to make fierie Lances.

THe vſe of theſe lances is alwaies required in all great fireworkes, wherefore here ſhall be deſcribed the manner of their making. Their cartouſhes are to be made as other cartouſhes for rockets; onely theſe may be made of paſtbord, and glued as they are a rowling, if it bee to make great ones, but if for little ones, then paper ſhall ſuffice, the cartouſhes being made, let them be filled with the dry compoſition preſcri-

bed for starres in the 8. chapter of this treatise, and prime them with wet gunpowder, & the lower end of the cartoush is commonly stopped with a peece of wood, to the end that they may bee nayled or stucke when they shall bee needfull the wood being about two inches long out of the cartoush.

CHAP.

Chap. XVI.

The manner how to make Rockets for the water.

TAke fire & water being two elements of contrary qualities, the one to the other cauſe the rockets which worke their effects in or vpon the water to appeare to the ſpectators more beautifull, and ſeem more rare and admirable, although that all ſorts of rockets being fired, will worke their effects vpon or vnder the water, but this onelie is to be noted, that thoſe which are made for

for the ayre, or for the ground, haue such strength and force, that beeing once kindled and cast into the water, they will consume themselues there, and not rise vp swimming as those which are made artificially for the water as followeth. To make good rockets for the water, the caliber of the mould ought to bee one inch of diameter, and in length eight inches, the breech to enter one inch, hauing no broach; the rowler for the cartoush shall be three quarters of an inch of diameter, and the charge shal be somewhat lesser then the cartoush being ready to bee filled as the others. Of two sorts of composition, you shall make one as followeth (if you desire to make a great fierie tayle appeare vpon the water, Then take one pound of salt-peter, half

a pound of powder-duſt, halfe a pound of brimſtone-duſt, and two ounces of charcoale-duſt: but if you deſire to haue it to burne cleere like a candle vpon the water, then take one pound of ſalt-peter, halfe a pound of brimſtone-duſt, and three ounces of powder-duſt, all theſe muſt be well mingled together, as all other compoſitions) and with either of theſe compoſitions, fill your cartouſh, and ioyne to the vpper end a ſauciſſon, and then couer it all with melted pitch, roſine, greaſe, or painting, to hinder the water from ſpoiling the paper: and to make it float and ſwim vpon the water, bind a rode about two foot long to it as to the others for the ayre. Now if that you deſire that this Rocket

change

charge his actions vpon the water, swimming now vpon the water, and now vnder the water, put here and there powder dust, powre to the quantity of halfe a spoonefull as you charge it; also may you make it change colour, now red and then white fire, onely changing the composition in filling it, and so the industrious may adde many changes and diuersities as they shall thinke fit: but if you are to make a great number for a great fireworke, then the plainest are the best, onely filling therewith the first composition, but they must be filled two or three fingers breadth with fine powder dust, to make them flye farre off, or else they must be made like rockets for the aire, and afterward charge them foure inches with composition made for water;

but

but to be the more certaine, it is best for those who haue great works, to make to trie one or two before they finish many, that the better they may attaine their desiignes, which with eie they may accomplish, if the rules prescribed be obserued; for as I think there is not one rule neglected apperteining to the fabrication of these fireworkes prescribed; and now I will set downe the manner how to make all sorts of ballouns and flying saucissons, which are absolutelie the beautifullest parts of fire-works for pleasure, and after them I will describe a braue fireworke for pleasure with the manner how to place, dispose and range euerie peece and part thereof, to make their play in order.

CHAP.

Chap. XVII.

How to make Girondells or fierie Wheeles.

A Girondell (or as ſome call it a fierie wheele) is often required in great or little fireworks for pleaſure, and therefore I haue thought fit and neceſſary to ſet downe their deſcription, as well as of al other parts of fireworkes: for according to the application of the Girondels in a Fireworke one may iudge of the Enginiers induſtrie, for being well applied, they adorn

adorne very much a fireworke, and being ill applied they ſpoyle all. And to make them, you muſt make wheels of wood as bigge as you pretend to make Girondells, and vnto thoſe wheeles bind faſt rockets of a meane bigneſſe, binding the mouth of one towards the tayle of the other, and ſo continuing vntill you haue filled your wheele quite round, which done, couer them with paper paſted very curiouſly about them, that the one taking fire, they take not fire altogether, but the mouth of one ſhall be left vncouered and ready primed, fit to take fire, the which ending ſhal giue fire backward to the next, and ſo one to the other, euery one his turne: there may bee bound fierie Lances to theſe Girondells either vpright, or neere overthwart,

which

which will shew diuersitie of fire the wheele turning: also there may bee added to these wheeles boxes of fire, prouided that they be artificially applyed in such manner, that they ballance the wheele equally, although the proper vse of girondeles, is onely to garnish the angles of a great Fire-worke, without much trouble, for that confusiō is too frequent in fire-workes; and therfore it shall be expedient to auoide the multitude of fire-workes too neere compacted together; but placing them as much distant as conueniently may be admitted, by which meanes you shall bee the better able to attaine your desiges pretended.

CHAP

CHAP. XVIII.

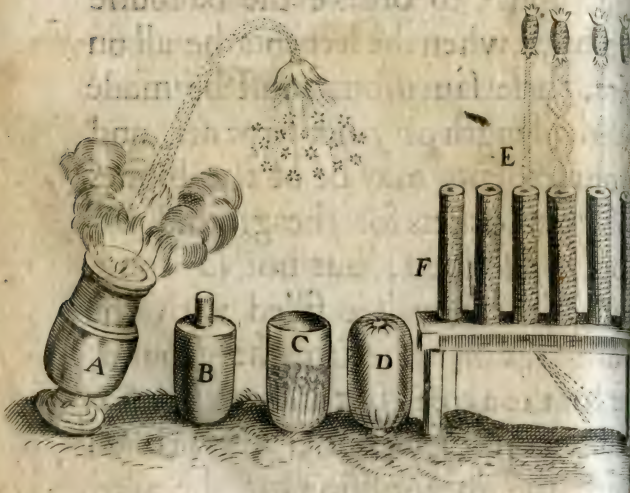
The manner how to make Ballouns.

THe ballouns being the perfecteſt part of all artificiall fire-workes for delight, I thought beſt to ſet their deſcription heere apart from the others, to the end that the learners might the better and more eaſier attaine to the knowledge and perfection thereof; and being that I haue alr eady deſcribed the morter, which is repreſented by the figure A, following, I will onely referre the reader to the ſecond chapter of the

first Treatise for warres, where he
he shall find sufficient instruction fo
the making of the instrument. But t
make a Balloune shall be required
woodden rowler, which is repre
sented by the figure B following
this rowler must be of such bigness
as you desire to make the inside o
your balloune; vpon which rowler
let there bee rowled as many past
bords as you shall think sufficient fo
strength being well glued together
and choake this cartoush at the on
end, leauing a little hole for a portfir
as shall follow, and glue it in. Thi
portfire shall be made iust like vnto
rocket for the ground, but only tha
the composition may be somewha
slower; as for the ayre, and to know
of what length this portfire ought
to be, it shall not bee amisse t
tr

try a balloune filled with earth; then your portfire being well fastned to the balloune, place all your serpents within it, putting nothing else amongst them, but onely one or two sauciſſons, to breake the balloune on high, when the serpents be all on fire, theſe sauciſſons muſt be made of the length of your serpents, and your serpents may be of the bignes of your rockets for the ground before preſcribed, but not ſo long, and they may bee filled with the compoſition either for the ground, or for the ayre: but it is to bee noted, that they muſt bee primed with the compoſition for the ayre, preſſing verie ſtronglie the priming powder into the throat or gorge of the serpents, if it bee put in drie: but if that were, then onely with

the end of a ſticke, or elſe with ones finger put in a little; as for other ſerpents and the two ſauciſſons ſhall haue their primings ſomewhat lon-



ger then the ſerpents, to the end that all the ſerpents may be a fire before that the balloune breake. The ſerpents being not made too long, one may

may put two or three rankes in one balloune, as appears by the figure C, or one ranke of serpents, and over them many Starres; all these things being thus disposed within the cartoush, let it be choaked at the other end; and then prime the balloun with cotten wieke steeped in gunpowder as the stoupel before spoken of; but this cotten must be well fastned to the end of the port-fire with strong packe-thread, which done, charge the balloune in your morter, as is taught in the 6. chap. of the first Treatise; and you may shoot it when you please. This balloun is represented perfect by the figure D, but if you will fill your ballouns with stars only, another manner of proceeding shall be required; for as you put in your starres into the cartoush, let

there bee powder-dust mingled amongst them here and there to giue fire to the starres, and to breake the balloune being vp in the aire. There is also another sort of ballouns to be made, but the expence of making thē is so excessiue, that few or none will be at the cost, yet the description shall now follow. In stead of serpents made of paper, you may haue them Iron about the bignes of your little finger, and one inch and a halfe of length, or two inches; and neer to the bottome there must be a double bottome in the middle whereof there shall be a little hole, that one may fill the space between the two bottoms with corned powder, and the rest is to be filled with a composition somewhat slow, the difference betweene those of Iron, and the former of paper,

per, is that many Iron ones may bee laid in a leſſer ſpace; but in ſtead of a paſtbord cartouſh, there muſt bee had a woodden box, made by a Turner, and couered with canuas and glue; the portfire muſt be made alſo of Iron, like to a little hat, hauing in the bottom two or three little holes to giue fire to the ſerpents; but for the expence of one of theſe, there may be made halfe a dozen of the others, nay neere a dozen, wherfore I would wiſh no man to trouble themſelues with this ſort, vnleſſe it be for the pleaſure of ſome great Prince.

Chap. XIX.

How to make flying Sauciſſons.

THe method which muſt be obſerued in making flying ſauciſſons, is moſt eaſie, prouided that one knoweth already the manner how to make the common ſort before preſcribed, for the cartouſhes are to bee made all alike; onely excepted that thoſe which are for flyers, be ſomewhat longer then the others, they are to be charged in like maner as the others, but the corned powder being put

put in, there must also be a litle powder-dust put after it, and beaten with a mallet, as the rockets for the ground yet let not more then the thickneſſe of a finger be of dust-powder, and then choake it almoſt quite together leauing onely a hole as big as a ſmall gooſe-quill, to which you ſhall put a little wet powder-dust for priming. They may be made otherwiſe, as followeth, which will make a more beautifull ſhew; firſt of all, you muſt charge the cartouſhes as the common ſauciſſons, and then choake them as the common leauing onely a little hole to take fire at, or if the hole chance to ſtop quite vp, open it with a bodkin, but the ſauciſſons being charged and choaked, there muſt be part of the cartouſh left ouer and aboue that which is charged, which

part

part shal be filled either with powder dust, or els with composition of rockets for the aire beaten wit a mallet, as before mentioned, I thinke it shall be needles to tell you that they ought to be couered with chord, being that it is sufficiently demonstrated before, it is to be noted that the saucissons which haue the powder within the choaking, doth turne wonderfully in the aire, but the other sort which haue the composition after the choaking, flye vp like to a rocket, almost carrying a great tayle after them but the tayle of the others sheweth but very little, they are both sorts represented by the figure E, in the 18. chapter.

CHAP

Chap. XX.

How to make ſhort Gunnes for the Sauciſſons.

HAving already treated ſufficintly and amply of the fabrication and making of the Morter, in the imitation whereof moſt eaſily may bee made Canons to ſhoote flying Sauciſſons very high in the aire, making them of the one or the other matter or ſtuffe preſcribed for the Morter in the ſecond chapter of the firſt Treatiſe, but the powder ſacke needs not

not, and the touch-hole ought to be in the middle of the bottome; also it shall be necessary that euery Canon haue a little breech to passe through a peece of wood, wherein they may be fastned, so that a port-fire may be layed from one to another, these are represented by the figure F, in the eighteenth chapter.

CHAP.

CHAP. XXI.

The manner how to disposé and build a great or little Fire-worke.

IT is a custome and vsual thing among the braue and skilfull Painters, to teach their apprentises how to draw limbs, or members, as the eye, the nose, the mouth, the eare, the hand, the foot, and afterward the whole bodie, and in like manner, the most learned

learned and famous Philosophers, beginning their schooles, teach their disciples what is *materia*, *forma*, & *primatio*; and afterward, *totum compositum*; and to imitate them in this Treatie, I haue taught the one after another, all the parties required are necessary for the composing & building of a beautifull fireworke for delight, hauing begun with the rockets for the ayre, afterward the rockets for the ground, the saucissons & rockets for the water, and following the ballouns and flying saucissons with all things belonging vnto them; and to auoyd falling into the old prouerbe (*Ex omnibus aliquid, & in toto nihil*: to know somthing of euery thing, and nothing perfectly) I haue here set downe after all these parts the description and manner how to assem-

ble,

ble, build and disposé any manner of artificiall fireworke great or little: and to begin, you must first cause to be built a scaffold trianguler, square,

round, or of such forme and bignes as you shall desire to haue your Fireworke, your scaffold being built, disposé thereupon your statues or figures

gures which shall be prepared for it; let them be made of osiers, and couered with paper or canuas, and curiously painted as here is represented in this figure. Mountains, buildings and many statues, all which are to be supposed, onely osiers and paper, or canuas painted, your figures or statues thus disposed vpon your scaffold, round about the flore therof, shal be layed your sauciſſons, being already fastned to peeces of timber, and to the pillers of your scaffold or raile, shall be fastned your firie lances one right vpward, and the other flat along, each distant, the one from the other about halfe a foot; and vnder the firie lances, let there be nayled a ranke of boxes of fire, which shal be ranged vpon peeces of wood as the sauciſſons; all your fireworkes be-

being thus disposed, you may plac
in the side which is of least esteeme
your partments of rockets made lik
vnto square chests, or long boxes, o
such bignes and length as shal be re
quired to hold those rockets which
you meane to place in each one: but
these boxes must haue a false bottom
full of holes for to passe euery rod of
euery rocket apart, and hauing fil-
led let the boxe (which by proper
name is called a partment) be coue-
red with a leafe or two of paper pa-
sted close; but to giue fire to the roc-
kets, let there be made a hole thorow
the partment, through it shal lpasse a
little peece of stoupel, or cottē wieke
and giuing fire to that, all the rockets
within the partment, fly out, and in
the same manner shall you giue fire
to all your fierie lances with a stou-

gurel going from the one to the other, let and as for your girondells, you shall red, giue fire to them with a match, as ou you desire that they should play, and n by this meanes all your fire-workes shall begin to play at once, except those parts which shall bee reserued without priming to be fiered by the hand, as best shall seeme to the artist or enginier, and so the industrious shall not faile to accomplish his designes, obseruing all the rules prescribed; which being at large laid down I will goe forward to the next chapter, and there shew how to make a most pretious vnguent for all manes of burnings, as well of common fire as of artificiall fire, if by hazard ani mischance arise,

PRO

CHAP. XXII.

A moſt pretious vnguent for any burning.

ET no man wonder if (hauing ended this Treatiſe of fireworkes) I take in hand to deſcribe a little part of Chirurgerie, which I confeſſe to haue taken out of a Treatiſe written by *Thybourel*, a Chirurgion of Loraine, and hauing made experience of this vnguent diuerſe times as well for burnings, as that for other accidents, I may ſay with boldnes & truth, that there was neuer the

like secret of this kind left to posteri-
tie, specially against hurts come by
fire, and which leaues lesse scarres af-
ter the healing of the places wound-
ded, and therefore I haue set downe
the very words which *Thybourel* hath
written in the last chapter of his 4th.
booke, intituled *Recueil de plusieurs*
machines militaires.

Take fresh hogges grease or lard, as much as you please, and boyle it, taking off the skim vntill there arise no more skim; then set the lard three or foure nights in the ayre abroad, after which it must be washed in running water, to take away the saltish nature, and also to cleanse it white, then melt it, and keepe it for your vse. Bacon may serue in stead of lard.

Other-

Otherwise.

The white of an egge or fresh butter being mingled together and well beaten to an oyle are excellent.

Another sort most excellent.

Take a stone of vnslacked lime (or otherwise called quicke lime) and let it dissolue in cleere water, and when the water is setled, powre it gently out from the lime through a linnen cloth, then put as much sallet oyle as you take water together, and beating it all to an oyle, you shal haue a most excellent vnguent for all kind of burnings, neither of these vnguents haue any scarre, but are precious remedies for the afflicted.

We haue seene Impostures couer sores with this water alone, but obseruing superstitious ceremonies, saying vaine prayers, but we assure the posteritie, that the water onely is sufficient to heale wounds and sores, onely washing them with it, and couering them with a linnen cloath wet in the same water, without any superstition, it doth modifie and percute, by which it doth supply nature, and doth heale sores better then our ordinary vnguents.

Thus may you see how this braue Chirurgion that set forth to the face of the world the perfection of this vnguent (which cannot be sufficient praised) confirming by his own confession, that the Chirurgions do not vse such good remedies in their shops and ordinarie operations; wherfore I haue set downe his owne words, that no man may esteeme mee

inuen-

inuenter of Calumnies, againſt the practitioners of Chirurgery, nor any others, as many now adayes ſeemes to write with ſerpents tongues, ſtinging vertue on euery ſide, againſt whō viperous venoms patience is the only antedote, leauing them to ſweat, vexe, and torment themſelues in their inſatiable rage; and to end my diſcourſe touching the perfection of this vnguent, I will aſſure all theſe who ſhall haue neede and make vſe thereof, that they ſhall find in operation what I haue here ſet downe in deſcription.

A Treatise of practicall Geometrie.

TO satisfie diuers of my friends and yeeld to their desires (whose treaties haue bin such powerfull commands to me, that I haue beene constrained to lay aside and forsake my own proper will and follow theirs, I haue set forth this little Treatise of practicall Geometrie to the view and censure of the world, which I acknowledge to be vnworthy of so many singular and industrious wits, as yearly spring vp in this Iland, and the adiacents there-

thereunto, notwithstanding I haue giuen way to their requests for their priuat contentment, and to assure the world that I haue nothing, no not my owne will proper to my selfe, but that I will follow as neere as possible I may the precepts and documents of that ancient, wise, and diuine Philosopher *Plato*, who saith, *Non nobis nati sumus, sed patriæ & amicis*; we are not borne for our selues, but for the seruice of our countrey and friends: then for the satisfaction of my friends and seruice of those who will accept these my labours, I haue cleerely and in few words set downe the manner how anie man (who hath neuer so little studied Geometrie) may take anie distance, or heighth, depth, or breadth with two little stickes, yea euen strawes, being laied a crosse, also

so I haue set downe a method how to take any kind of heighth, distance or depth, with the Sector without anie arithmetike or rule thereof: and also by the *sines tangents* and *secants*, the whole beeing very portable, to refresh the memorie, & to streng-then and augment the knowledge of those who (for want of practise) haue not the perfect vse of those instruments: then first of all I will set downe the manner how to accomodate and dispose the sticks, twiggs, or strawes for the measuring of any distance.

The method how to make the Crosse.

HAuing two stickes, the one long, and the other somewhat short as are represented in the figure following by C F, and D E, then marke vpon the sticke C F, points the one distant from the other precisely, halfe the length of D E, and let there be a hole made through the sticke D E, so that it may slide vpon C F, from end to end, and you shall know the two parts of the crosse by these names, the

the longest part CF, shall be called the index, and the shortest D E, the crosse. Now if you haue any heights to take, then fasten to one end of the crosse, as to D, a perpendicular or plummet, and for the more easie and iust operation, you should haue a foot to support the crosse; the instrument being thus prepared, you may measure with great facility either heights breadth, or depth, as followeth.

PROP.

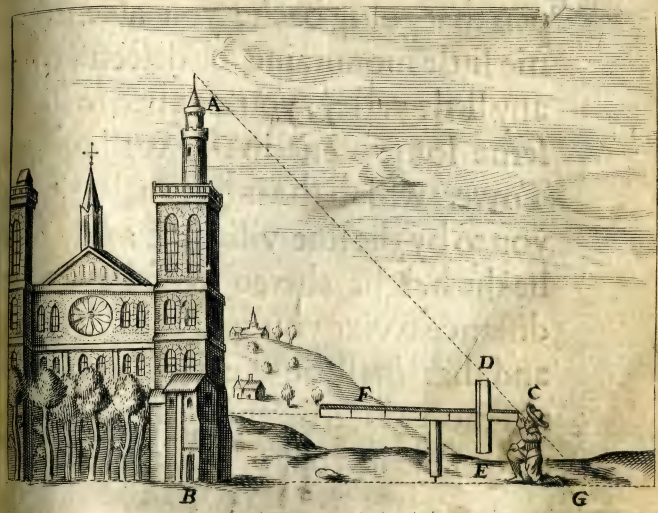
PROPOSITION I.

How to take a height accessible.

LEt it be proposed to take the height of the Tower A B, to the base or foot whereof one may easilie approach; dispose the crosse of your instrument in such sort that D C E be of equall distance there one from the other; as thus, settle your crosse vpon the first point of the index; then setting the instrument to your eye, goe either neerer, or retire farther from the obiect you desire

sire to measure vntill you see A the highest part thereof by the two extremities of the crosse C D, (the inden being paralled to the earth) which will happen in the point C, and not else-where: that being measured, will be alwayes the iust height of the Tower required, onelie obserue that you must alwayes adde to the distance betweene you and the Tower the length of the foot, which supporteth your instrument, and so you shall haue preciselie the heighth required: for scarce euer will it happen, that the instrument may be placed leuell with the base or foote of the height required, but if that should chance to be, then the extremitie of the index C would ariue in the point G, and so nothing to be added, but onelie measure the distance be-

betweene G and B, and that would be the iuſt height required; but if it chance that you may not plant the inſtrument in the point C, by reaſon



of ſome inconueniences which may happen retire further backe, and put forward the croſſe to the ſecond point of the index, and then accord

your

your visuele lines to see the point A, (the index alwaies being paralel to the ground) which then will happen wice the height required, distant from the foot thereof: but if it happen that going backe you ascend any little mountaine, or descend into any little valley, you are then to obserue some point in the wall of the Tower, which the index shall direct you to by the line visuel, & ad de onlie the height thereof vnto halfe the distance twixt you and the Tower, and that shall be the height required most exactlie: and thus you shall neuer faile in your operations.

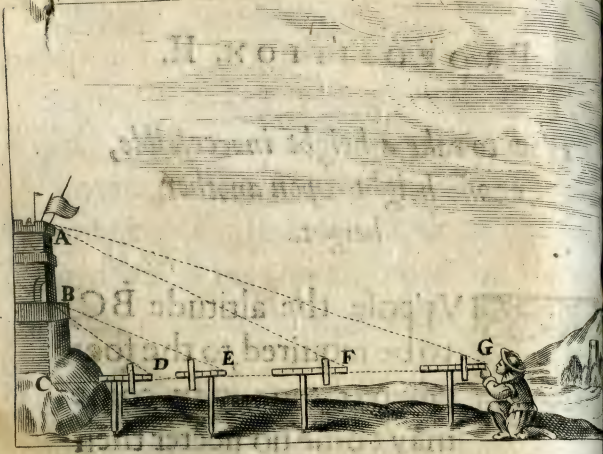
PROP.

PROPOSITION. II.

How to take a height inacceſsible, or one height vpon another height.

SVppoſe the altitude BC, to be required, to the foot whereof one may come may come no neerer then to the point D, then at the point D, accord your viſuell lines an B and C, the index being alwaies leuell with the ground and the croſſe fixed vpon the firſt marks or point of the index,

then set a marke there in D, and going backe towards F, as farre as E, and put forward the crosse to the second point of the index, and then direct



your lines visuel againe in B and in C, which will arriue in E, and no elsewhere, then measure the distance betweene D E, which will be the al

titud

titude precisely required, but if you desire the heighth of the Tower B, and mountaine leuell with the foote of your instrument, then you must adde the length of the staffe, which supporteth it as in former obseruations. And to haue the altitude A B vpon the top of B C, you must take two other obseruations in F G as before, setting your instrument in F, the crosse being fixed vpon the second point of the index, and direct your visuell lines in A and in C, and then set vp a mark in F, and goe backe, putting forward the crosse to the third point of the index, and direct your visuell lines againe in A and in C, which will happen in G, and not elsewhere, then measure the distance betweene F G, which shall bee equall to the

altitude of the Tower AC, and hauing taken already the altitude BC, you may verie easilie substract the little altitude BC from the greater Altitude AC, and then will rest the altitude AB, which is required.

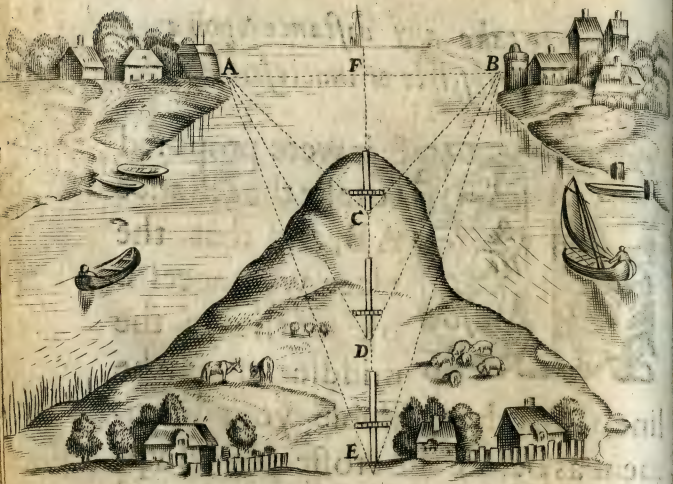
PROP.

PROP. III.

How to take any distance vpon a place accessible or inaccessible.

IF it were proposed to take the distance AB, and that the place were accessible onelie in the middle vpon the line CF, then dispose your instrument as before the crosse placed vpon the first point of the index; and going forward or backward vpon the line CF, direct your visuel lines in A and in B by the two extreamities of the crosse, the end of the index

resting against your eie, then measure the distance betweene you and the point F, and that shall be iust half the distance required betweene A B, but



if the place be inaccessible, so that you may not approch neerer then the point D, put forward the crosse to the second point of the index, & then dire&

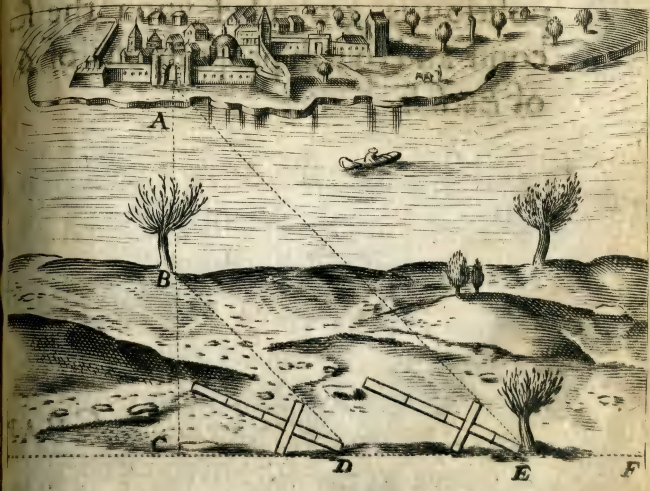
direct your visuel lines to AB, and leaue a marke at D, and put forward the crosse one point more, and going backe vpon the line D E, vntill you may direct your visuel lines by the extreamities of the crosse againe in A and B, then measure the distance between D E, and that will be halfe the distance betweene AB, and so may you operate going backe, and putting forward the crosse.

PROPOSITION IV.

Another manner how to take a distance inaccessible.

SVppose the distance AB to bee taken, and that B is the neereſt place that may berequired, then there muſt be ſet a marke, and withdrawing backward in a ſtraight line towards C, and there againe plant another marke at C, then going right towards one ſide, as towards F, counting your places equall to the number which you haue alreadie found B and C, and there direct your

your visuel lines in B & C, as in this figure at D, leauing there a mark, goe straight along towards F, not mouing the crosse of your instrument,



and going along make trial where your visuel lines may be directed again in A and in C, which will be in the point E, and not else-where, then

then leaue there a marke, and measure the distance betweene D E, and that shall bee the distance which you require, which is A B, the demonstration of this proposition is grounded vpon the second and fourth propositions of 6 of *Euclide*.

CHAP

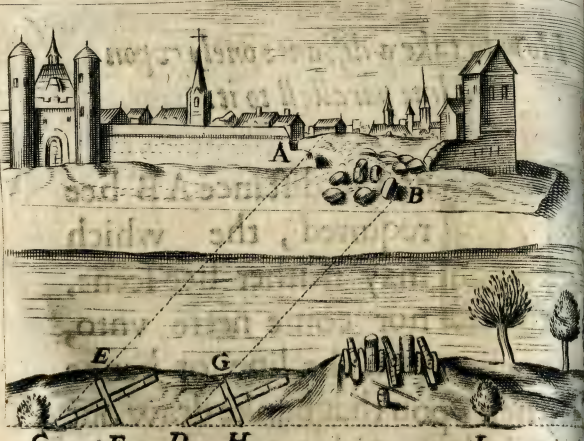
Prop. V.

How to take a distance onely vpon a line parallell to it.

LEt the distance AB bee required, the which may neither bee seene, nor come neere vnto, but onelie vpon the line or banke CK, then vpon that banke draw out a straight line with markes, as the line CK, paralell to the wall AB, and set a marke in K, then goe backe towards D, and direct your visuel lines in B and in K, by the extreamities of the crosse GH, then leauing the crosse

in

in the same state and a marke at D, withdraw your selfe further back towards C, vntill you may direct your visuel lines to A and K, which will



happen in C, and not elsewhere, and leaue there another marke, then measure the distance betweene C D, and the same shall bee the breach A B,

qua

quall to C D, and the demonstration of this proposition is grounded in the 29. and 33. propositions of the 1. of *Euclide*.

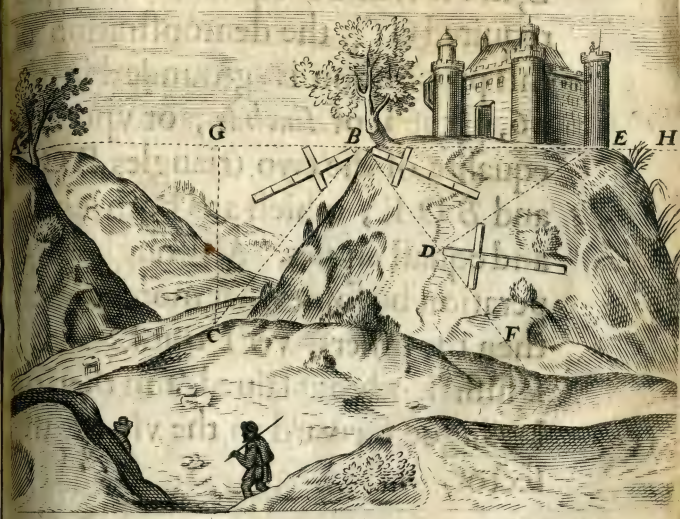
PROP. VIII.

How to take the depth of a valley.

TO take the depth of a Valley, there is somewhat more difficult then in the former operations, because there are more obseruations to bee made, and to begin you must from the point B obserue in some place op-

oppoſite a marke leuell with the horiſon as A, the leuell whereof you may eaſilie take at this inſtrument, as is taught in the ſecond propoſition by the helpe of the plumbet: then from the point *B*, take the diſtance *B* C, as in the fift propoſition, or elſe mecanikelie, which being done, direct your viſuel lines from *B* to A, and to C, and leauing the inſtrument in ſame ſtate, turning your ſelfe about, frame the ſame angle vpon the plaine, which will be FBH, then plant markes vpon the lines *B* F and *B* H, and vpon the line *B* H, count as many paces or fathoms as you ſhall haue found betweene *B* and *C*, and at the end of your paces, ſet a marke, which will bee at E, this being

being done, disposse your instrument to make a right angle, placing the crosse vpon the first point of the index, for the crosse maketh alwaies a



right angle when the crosse is vpon the first point. The instrument being thus disposed, walke vpon the line B F, vntill you may direct your visu-

ell

all lines (by the extreamities of the crosse) to B and E, or els to F E, which will happen in D, and no where else, then measure the line D E, and it will be equall to the depth required G C, the demonstration of this proposition is grounded in the 26, of the 1. of *Euclide*, or vpon the equalite of the two triangles B G C, and B D E, which are both equall and equall angles. Although this operation be somewhat more obscure then the others, yet I thinke that it is sufficiently explained, and therfore I will goe forward to the vse of the sector.

PROP.

PROP. IX.

The manner how to take either distance or altitude with the Sector.

SVppose the altitude A D were to be taken to the foot whereof you may approch open the Sector 45 adding to it the sights then going forward or backward vpon the line DI, vntill you may see the highest part of the altitude A, through the two vpper sights, the inferior branch of the Sector, being paralell to the earth or

horiſon, then meaſure the diſtance betweene the center of the Sector and the Tower, adding to that diſtance the length of the leg, which

ſupporteth your Sector, and that ſhall be the altitude required, as appeareth in the figure following *A B*, and *B C* are of equall diſtance, and adding the

length

length of the foot of the sector, you will find, that it will be height of B D, which doth accompliſh the altitude of the Tower. But to take a diſtance in any plaine, as in the figure precedent, the ſame operation may be vſed, except onely the two branches of the ſector ſhall be turned paralell to the horiſon or ground, hauing firſt made a right angle at the point G, or you may operate otherwiſe, firſt of all prolong a ſtraight line as E G H of what length you pleaſe, then open your ſector to a right angle, and ſet it the point G, ſo that you may ſee through two ſights the point E, and where the line viſuel of the other two ſights ſtrikes along, ſet vp a merke as in I, then goe towards it, and at your pleaſure in the ſame line, ſet your ſector opening it,

so that you may see the point E and G, and keeping your instrument at the same width, & in the same place place, only turne it to the other side, so that you may see the point G, thorow the sights which before saw E, and where the other visuell line shall cut the first line EGH, set a marke which will be in H precisely, and that shall be the distance required G E, the demonstration of this proposition is grounded vpon the 4. and 26. of the 1. of *Euclide*.

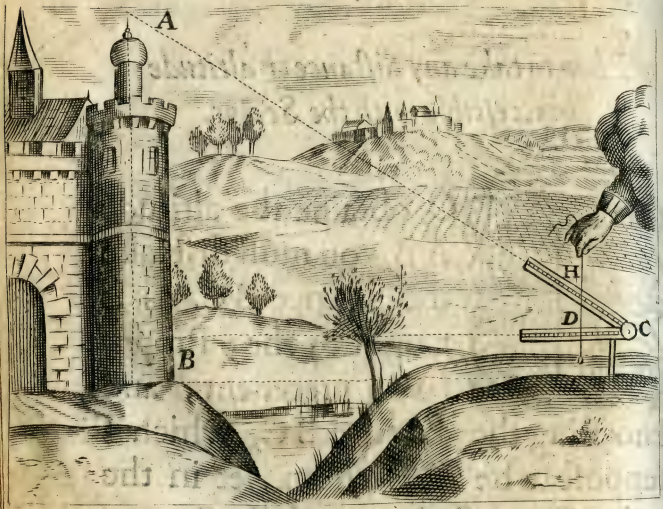
PROP.

Prop. X.

How to take any distance or altitude inaccessible with the Sector.

TO obtaine the altitude A B, you must first take the distance B C. as is taught by the 9. Proposition precedent, and knowing the distance B C, which I suppose to be 100 fathom, set in the point C your Sector, and direct your visuell line through the two vpper sights to the top of the altitude A, and let the branch of the Sector be paralel with the ground, then leaving your

instrument at the same width, let fall a perpendicular line vpon the line of the Sector divided into equall parts, passing by the 100 number of the infe-



rior branch noted D, and note what nūber the perpendicular doth cut vpon the vpper branch of the Sector noted H, which I suppose here to bee

the

the 150 part or number, and then set the two points of a paire of compasses vpon the two numbers, to wit, the one point vpon 100, and the other point vpon 150. of the equall parties, then transport the points of the compasse all along one branch of the Sector vpon the line of equall parties, and the two points shall denote as many parties vpon the line of the Sector as the Towre doth containe fathoms in altitude, adding the length of the foote which supporteth the Sector, the demonstration of this Proposition is grounded vpon the 4. Proposition of the 6. of *Euclide*.

Prop. XI.

Of Sines, Secants, and Tangents.

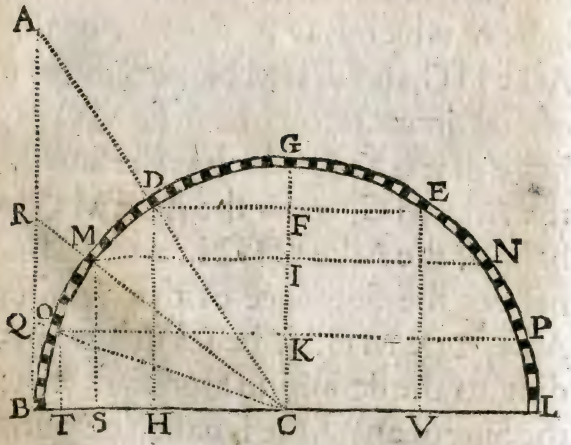
Because the most noble, most artificiall, and most certaine way of taking of Altitudes, Distances, or other Dimentions, is by Sines, Secants, or Tangents, I haue set downe their operations in such Propositions as are vsuall in this subiect at the end of this Treatise of *Practicall Geometrie*, and before I enter on the method of operation, it is necessary to define what the said Sines, Secants, & Tangents are.

1. A right Sine is halfe the Subtence of of the double Arke. A

A Subtence, sometimes called a Cord, is a right line drawne from any part of the Circumference of a Circle, vnto any other part of the same Circumference, so the right line D E is the Subtence or Cord of the Ark DGH halfe of which is D F, the Sine of the Arke D G; and so is M N the Subtence of the Circumference or Arke M G N, halfe of it is M I, which is the Sine of the Arke M G; now the Arke M G is halfe of the Arke M G N, and M I is halfe of the Subtence of that double Arke, *viz.* M G N; hence it is according to the definition aforesaid, that the Sine of any Arke is halfe the Subtence of the double Arke; by the same reason O T is the Sine of the Arke B O and M S is the Sine of the Arke B O M and so of others.

Note that the Sine of any Arke lesse then

then a Quadrant is alſo the Sine of the complement of that Arke vnto a Semicircle, ſo the Sine of BO 20 degrees being OT the ſame OT is alſo the



Sine of the Arke OGL 160 degrees, for that the Subtence of an Arke of a Circle is common both to the leſſer Segment that it ſubtendeth, and alſo

to

to the greater, and therefore halfe of the Subtence wich is the Sine ſhall be common vnto halfe the leſſer Segment and alſo vnto halfe of the greater, which two halfes put together make a Semicircle; and therefore the one is the Complement of the other.

Note further that the totall Sine, the Sine of 90, or the Radius, is nothing elſe but the Semidiameter of any Circle, *viz.* C B, or C G.

If a line be drawne touch a Circle, it is called a Tangent, (*a tango*) as the line A B toucheth the Circumference of the Circle in B, and ſo A B is called a Tangent line, and is ſituated on the Terme of the Radius C B, and perpendicular thereto, by the 18 Propoſition of the 3. of *Euclid.*

2. The Secant of an Arke is a line contained betweene the Center and the

the line Tangent, so that it passe by the given Arke, so if B O be a given Arke, C Q is the Secant thereof, and if B M be a given Arke, then is C R the Secant thereof.

3. The Tangent of an Arke is a line contained betweene the tearme of the Secant, and the touch point, so *B Q* is the Tangent of the Arke B O, and B R is the Tangent of the Arke B M, &c.

PROP.

PROPOSITION. XII.

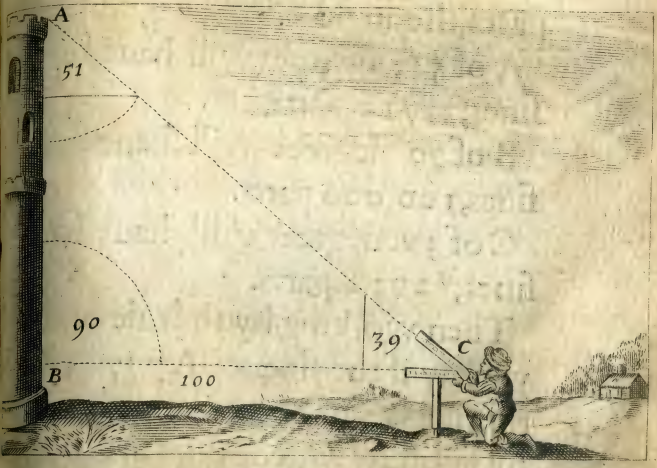
How to take any altitude or distance by the Sines, Tangents and Secants.

FIrst of all is to bee noted that in all triangles as each side is the one to the other, even so each sine will bee one to the other: that is to say, each sine of a triangle equilaterall shall bee equall amongst themselues, or one sine, as the sides of that triangle are all equall, and

and the sine of a Scalene triangle shall be all inequall and different amongst themselues, as the three sides of the triangle are different one from another. Now for operation let it be proposed to take the Altitude A B, to the base or foundation whereof you may well approach, then there begin to measure your paces or fathoms from the base B to some place in the plaine which I suppose to be C, and there set your instrument either Sector, Graphometer, or anie other with which you may take the degrees of an angle, and in the point C, take that angle which is found to be of 39 degrees, & the angle B is already knowne to bee of 90. degrees, the Tower standing vpright: now rests to know the degrees of the angle A, which to obtaine adde 90. to 39. and it maketh 129.

which

which you must substract from 180. and then will rest 51. which the angle A containeth, and so the three angles are knowne, and the one side of



he triangle BC, is also knowne to ontaine as I here suppose a hundred athom, and to know the quantity of he other two sides AB and AC, by the

the sines, tangents, or secants, you must seeke in a table of sines the sines of each angle which will be found as followeth, the sine totale, or the demi-diameter being supposed of 100,000 parts, the angle.

A of 51, degrees will haue for his sines, 77715, parts.

B of 90. degrees will haue for his sines, 100,000. parts.

C of 39. degrees will haue for his sines, 62932. parts.

Then working by the rule of three you say if the sines of A 77715. giue the side BC of 100 fathoms, how many fathoms will the sines of C, 62932. for the side AB, and dispose your rule of three as followeth. If 77715. 100. 62932. And hauing multiplied the second number by the third or the third by the second, and di-

vi-

ded the product by the first number, and the quotient of the diuision will be for the side AB 80 fathoms, 70 inches, 4 lines and $\frac{11}{15}$ parts of a line And to find out the side AC, you must operate in the same manner by the rule of three, & say if the sine A of 79715 giues the side BC of 100 fathoms, how many fathoms will the sine B giue, which is 100, 000. for the side AC, and hauing multiplied the second number by the third, and diuided the product by the first, the quotient will be 128 fathoms, 48 inches, 7 lines, & $\frac{4875}{7971.5}$ part of a line, which is almost one line for the side AC, and thus may you know any kind of distance with great facilitie, onely knowing the angles and one side.

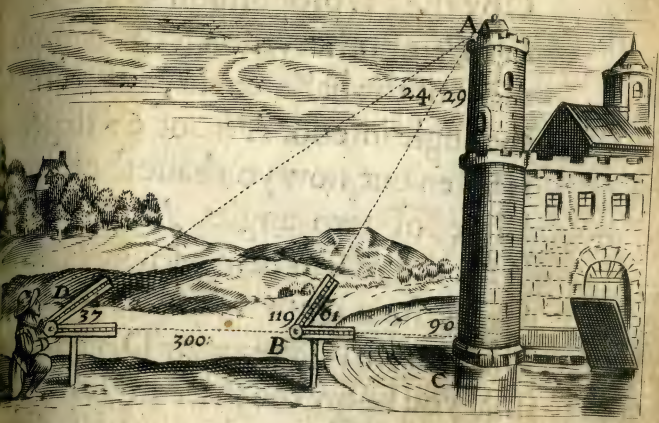
PROP.

PROP. XIII.

How to take any altitude or distance inaccessible by the sines.

LEt the altitude A C be proposed to be taken, and the neerest comming to it is B, then in that point B, take the angle A B C, as in the chapter before, which is of 61. degrees, then assemble 61. with 90. the right angle opposite and the whole is 151, which you must substract from 180, and then will rest 29 for the angle A, and so the three angles of the triang

triangle are known, but neither side; and therefore to know one of the sides, that wee may operate by the sines, tangents and secants, retir-



further backe or aside to D, and measure your paces or fathoms from B to D, which I suppose here to bee 300. paces, and in the point D, take the

angle ADB, which is 37. degrees, and then may know that the angle exterior ABD, is of a hundred and nineteene degrees, for it is equall to the two interior angles ABC and BAC by the 32. proposition of the 1. of *Euclide*, or otherwise it is the complement of the halfe circle, of which the angle interior ABC of 61 degrees is taken out, now you haue the knowledge of two angles ADB, and DAB, the which being ioyned, substract them from 180. and then the third angle will remaine DA*B*, then shal you know the three angles of the triangle A*B*D, and one of the sides by which you may come to the knowlege of the side A*B* of the first triangle A*BC* by the sine, and by the knowledge of the side A*B*, you may also know the side *AC*, by the sines

tan

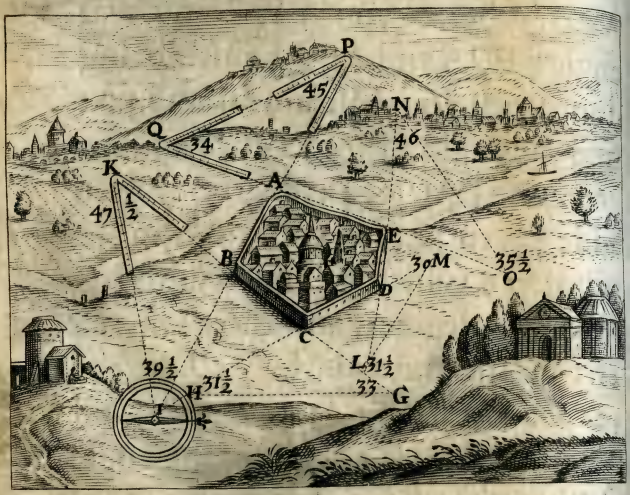
tangents and ſecants, as in the precedent chapter: and ſo in all manner of altitudes or diſtances, acceſſibles or inacceſſibles, and it is to bee noted, that one is not boũd to wright backward, taking the ſecond obſeruation in D, but at the pleaſure of the workeman to make choiſe of the faireſt place in the field, ſo I thinke no difficulty ſhal be found in theſe works

The manner how to take the plane of a towne, or any place out of musket-shot.

SVppose you were to take the plane *ABCDE*; first, hauing considered that the scituation of the plane hath a crooked arke *BAE*; those two lines must be supposed straight as EQ and *B P*, making an obtuse angle at the point A, and being farre off from this plane in the point P, consider that the lines *P B* and *Q E*, make but one angle in the point A, the leauing a marke at P, withdraw from thence into some other place of field where

where your eye may rightly meete with the line *AE*, which will happen in *Q* where you must set another mark now consider that if a line be drawne from *Q* to P, it will forme a triangle APQ, whereof you may know two angles, PQA and APQ which being done with your instrument, and you find the angle APQ to bee of 45. degrees, and PAQ of 34. degrees, then adde 45. to 34. and commeth in the whole 79. which you must substract from 180 degrees, and there will rest 101 for the third angle *PAQ* by the 32. proposition, lib. 1. of *Euclide*, and the angle *EAB* is equall to the angle *PAQ* by the 15. proposition 1. then let vs conclude that we haue the angle *BAE* of 101. degrees, which was vnknowne, then shall it be necessary in the place noted H, to know how

the side CD is scituated in respect of the parts of the world, and with a declinatorie we shall find it to be seated North, West & Southeast, which



shall serue vs for the knowledge of all the rest: and in the former manner may be taken all the other angles of the plane proposed, and to haue the

the distance of each side of the plane, you must measure one onely as before taught, which I suppose it shall be B*C*, which shall bee found to bee 100 fathoms, and hauing found a side homologe to it or like to it, and diuided into an hundred parts equally, it shall serue for a scale to measure all the rest by.

CHAP. I.

A treaty of fortifications as well regularly as irregularly.

IT is not my intention to treate here of all manner of fortifications, but onely of those which by the generall and common opinions are held and approoued to bee the best for the defence and conseruation of deseruing places; and to begin this Treatise, I will set downe certaine rules which

are

are now held for maximes of the best fortifications.

Let the flanked angle be open 90. degrees, or the neereſt to 90. that may be it is the angle A in the next trianguler figure.

Let the flanking angle be not aboue 150. degrees open, but the leſſer, ſhall alwayes be the beſt, this angle is BLC in the ſame figure.

Let not the line of defence be longer then musket-ſhot, which is 100, or 110 fathom, it is CK or BI in the ſame figure.

The largeſt necke or gorge of a baſtion or bulwarke is alwayes the beſt and the longeſt flanke lines, ſpecially if eares be to be built vpon them, C N or M I are noſe lines

Now ſhal follow al the denomina-

tions

tions of fortifications for the better intelligence of the better treating of them.

Chap. II.

Denominations of the parties of Fortifications.

A Flanked angle is the point of a bulwarke in the figure following, it is the angle SBN.

A flanking angle is BLC, which is made by two lines of defence meeting in the point L.

A line of defence is the distance from

from the flanke to the angle flanked, as here B I, or C K.

The flanke is K or L.

The line of the flanke is K N or I M.

The curtine is the ſtrait line drawne from one flanke to the other, as here K I.

The ſhoulder of a bulwarke is N or M.

The pane of a bulwarke is B N.

The eare is alwayes built vpon the line of the flanke, as in the ſecond figure following.

The capital or chief line is B I or F C

Baſtion or bulwarke is a piece contained within two lines, two panes, and two flankes.

The necke or gorge of a baſtion is the diſtance betweene the two flanks for the entrie into the baſtion.

A rampard is the earth raiſed againſt the

the wall in the inside to strengthen it against Canon shot.

The parapet is the elevation above the string of the wall.

The counter escarp is the exterior brim of the towne ditch.

A halfe moone is a peece loose from the towne raised of earth, and inuironed with a ditch to hinder the assault of the enemies, it is sometimes made in forme trianguler, but sometimes oblong as occasion is, now shall follow the Treatise of the regular forts, and first of all the trianguler.

CHAP.

CHAP. III.

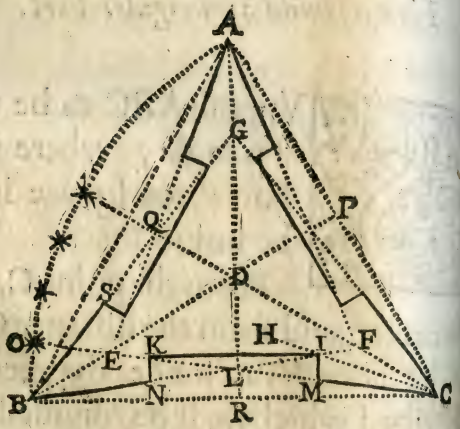
How to build a trianguler Fort.

SVppoſe ABC to be the Triangle, where in a Fort three ſquare is to be built.

From the point C, as the center, and from the diſtance CB, let the arke BTA for 60. degrees be deſcribed, which ſhall be diuided into two equall parts at the point T. And againe, the arke BT into foure other equall parts, and OB ſhall bee an arke of 7½ degrees, by which draw the line CO, and it ſhall forme the diminiſhed

minished angle OCB of $7\frac{1}{2}$ degrees.

Then diuide each side of the triangle in two equall parts by the points *QPR*, and draw the strait lin



QC. PB. AR. & the center of the fo
shal be *D*, & the intersection E, whic
is made by the line OC, shal be cent
of one bastion, and the line BE is th

Cap

Capitall line which shal be transported into *CF* and *AG*, then draw the straight lines BF, FA. CG. and AE, which shal forme the diminished angles, and become lines of defence.

And to find the point for the flanke diuide the angle *QCE* in two equall parts by the straight lines *CH*, which teacheth vs the point I, for the flanke and then take the distance FI, and carry it to EK, and the point K shall be another flanke, then draw the lines of the flankes KN and IM perpendicularly to the courtine KI, which is drawn from the flanke K to the flank I, and the same vpon the two other sides, and you shall haue the triangular fort perfect.

The flanked angle is of 45. degrees, and the flanking angle is 165. degrees

open

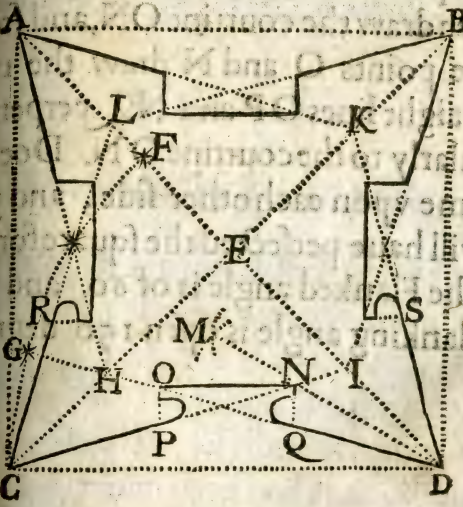
open, which is somewhat farre from the best maximes of fortifications.

Chap. IV.

How to build a square Fort.

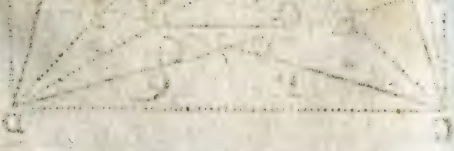
Set the square ABCD b[e] in which you desire to build the Fort, draw the two diagonales AD.CB, which cut E the center of the Fort from the point D as center, and from the distance DC, let the arke *CGF* bee drawne, which shall bee diuided in three equall parts, and from the point G draw the straight line GD, which formeth

formeth the diminished angle GDC of 15. degrees, and the intersection of the line *GD* in *H* doth shew the line capitoll *CH*, which shall be transpor-



ted into I K L, and then draw the straight lines *CI*. *DH* and their fellowes, and to find the point for the Flanke, diuide the angle FDG in two

equall parts by the line DM, which cutting the line *CI* doth shew vs the point N for the Flanke, then take the distance IN, and beare it to HO, and the point O shall be another Flanke, then draw the courtine ON, and from the points O and N draw the two straight lines OP and NQ perpendicularly to the courtine ON. Doe the same vpon each other side, and you will haue perfected the square fortres The Flanked angle is of 60. and the Flanking angle is open 150. degrees.

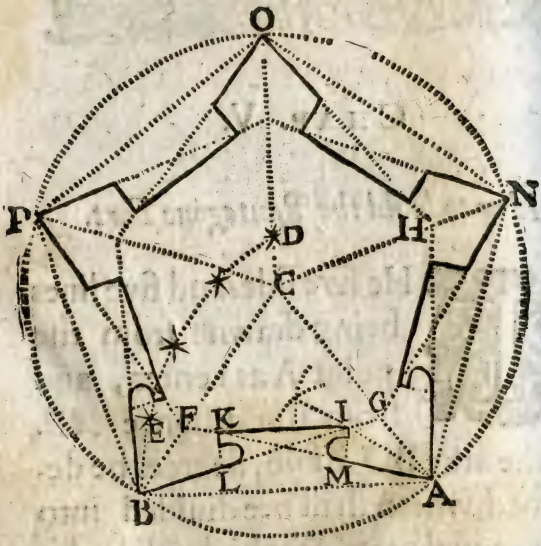


CHAP. V.

How to build the Pantagone Fort.

THe five sides and five lines being drawne from the point A as center, and from the distance *AB*. let the arke BD of 60. degrees be described, which shall bee diuided into foure equal parts, of which BE is one and from the point E, draw the right line AE, which cutting the line *BC* at the point F, doth giue the part *BF* for the capitall line; which distance

must be transported to the other lines AG, &c. then from the point B draw the straight line BG, and so the



others which shall bee lines of de-
fence.

And to find the Flanke, diuide the
angle

angle EAC in two equal parts by the right line HA and the interſection which it maketh vpon the line BG at the point I ſhall be the Flanke, then take the diſtance GI, and tranſport it into FK, and ſo to I G, and the point K ſhall be a Flanke and the point I, then draw the line KI, which ſhall be a courtine, and draw the lines KL and IM, which ſhalbe the Flank lines being drawne perpendicularly to the courtine, and doing the ſame to euery other ſide, you ſhall haue the deſired Fort.

Chap. VI.

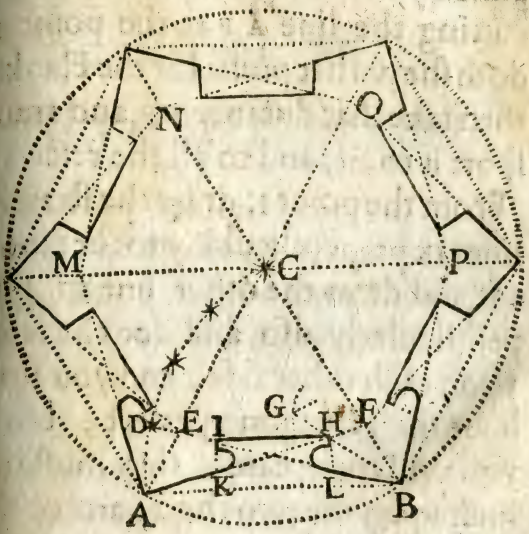
How to build the Fort Hexagone.

HAuing diuided your circle into ſixe equall parts, and drawne the ſixe ſtraight diagonall lines and the ſixe ſides.

From the point B as center, & from the diſtance AB, let the arke ADC of 60. degrees be deſcribed, and it ſhall be diuided into foure equall parts, whereof AD is one.

From the point D, draw the ſtraight line DB, which cutting the line AC at the pont E, doth giue the diſtance

stance AE for the capitall line, then transport that distance to BF.



and so round to each angle, & draw the straight lines DB AF and the others like vnto them which shall be

hereafter the lines of defence.

And to find the point for the Flank diuide the angle DBC in two equall parts by the ſtraight line GB, which cutting the line A F at the point H doth ſhew that point for the Flanke, then take that diſtance HF, and tranſport it to EI, and to all the reſt.

From the point I, draw the ſtraight lines IK perpendicularly to the curtin I H, and draw the other line HL perpendicularly alſo, and doe the ſame vpon each other ſide, and you ſhall haue the Hexagone perfect, but if you will make eares, they muſt bee built vpon the two third parts of the lines of the Flanke IK HL as appeares at.

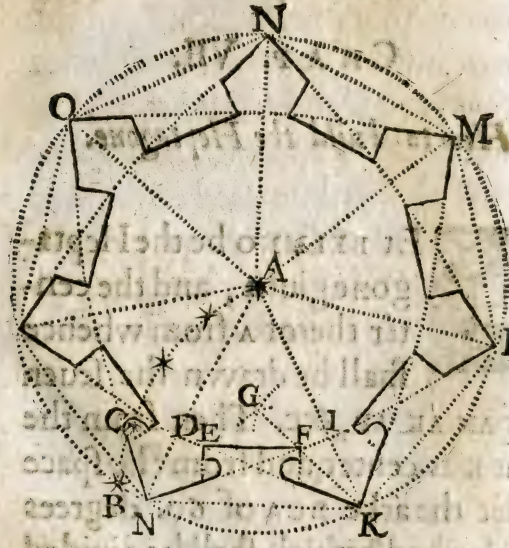
CHAP.

CHAP. VII.

How to build the Heptagone.

LET BKLMNO be the Heptagone giuen, and the center therof A from whence shall be drawn the seuen lines AN. AK. AP, &c. Then from the point K as center, and from the space KB, let the arke BCA of 60. degrees be described, which shall be diuided into foure equall parts, whereof BC shall be one of 15 degrees, from the point C draw the right line CK, the which cutting the line AN, at the point

point D, giueth that part for the ca-pitall line. Then take the distance ND, and carrie it to KI, and to al the



rest likewise, then from the point N draw the right line NI, which shall be the line of defence, and all the o-thers like vnto it.

And

And to find the point for the flank, diuide the angle AKC in two equall parts by the right line GK, which cutting the right line NI at the point F sheweth that intersection F, for the point of the flanke take the distance and cary it to D and E, and the point E shall be another Flanke, then draw from E to F the line (which makes the courtine) then the two perpendicular lines for the Flanke lines: whereupon shall be built the eares, and doing the same vpon each side your fort shal be perfect, as required.

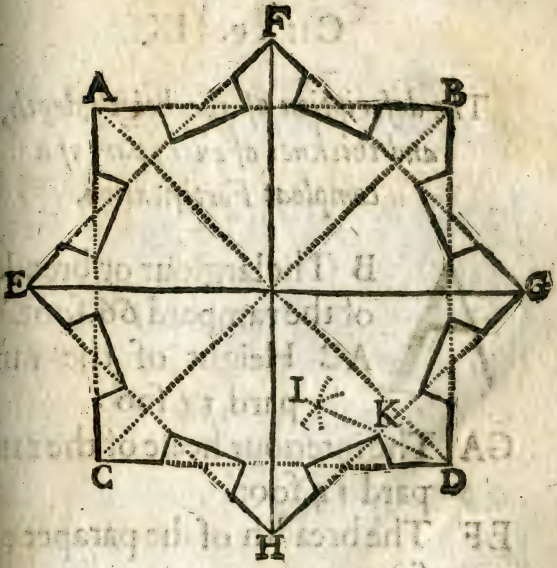
CHAP.

Chap. VIII.

How to build the Octogone.

First let the ſquare AB CD be made, & then the ſquare E F G H.

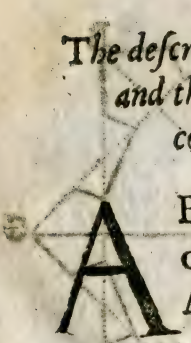
And to finde the place for the Flanke, diuide the angle ADC by the ſtrait line DI, and the interſection K ſheweth the point for the Flanke, as in the Forts precedent, and ſo tranſport to euery ſide as in the other, and you ſhall haue the Fort finiſhed.



CHAP.

CHAP. IX.

The description of the heigth, depth, and thicknes of euery part of a compleat Fortification.



AB The largiour or breadth of the rampard 66. foot.

AC Height of the rampard, 14. foot.

GA The interiour heele of the rampard 14. foot.

EF The breadth of the parapet 20. foot.

EH Height of the parapet 6. foot.

BI. The exterior heele of the parapet 7. foot.

IK. The couered walke vnder the falſe bray 20 foot.

KL

KL The parapet of the false bray 20 foot.

MN The breadth of the ditch 120 foot, & the depth therof ought to be 10 foot.

NO The heele of the ditch 10 foot.

OP The couered walk of the counterescarpe.

PQ The counter escarpe 6. foot of height.

CHAP.

Q
P
O
N
M
L
K
I
H
F
E
C
B
A

CHAP. X.

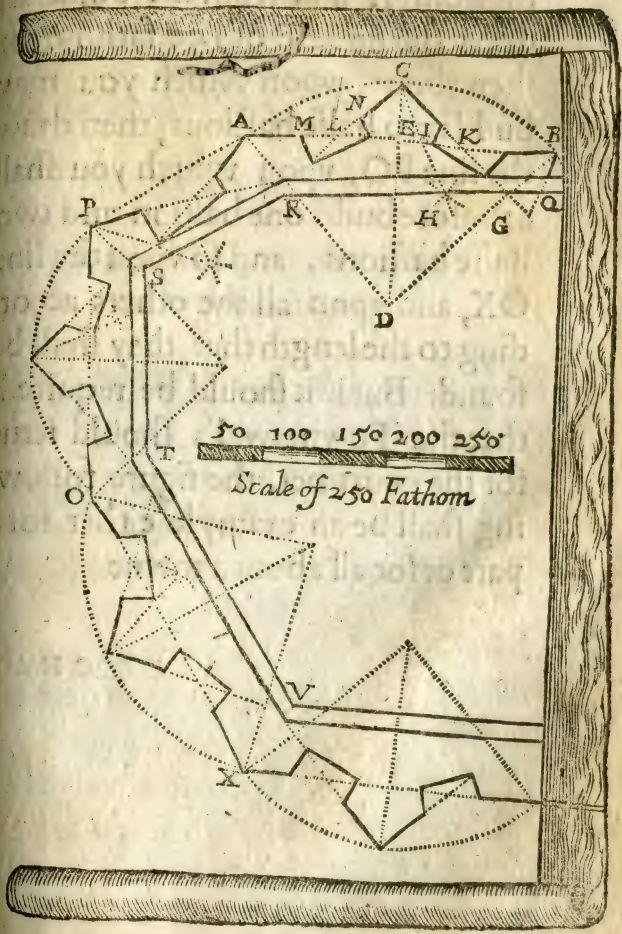
The manner how to fortifie places irregularly.

VPon a line of 100. fathoms is to be made a tenayle; vpon a line of 150. fathoms two half baſtions. Vpon a line of 200. fathoms a double tenayle. Vpon a line of 250. fathoms or therabout is to be made one baſtion, and two halfe baſtions.

CHAP. XI.

A Fortification irregular.

SVppoſe the place QR STV to bee fortified without diminiſhing the place, and having taken it vpon a faire ſheet of paper and well conſidered, all the meaſures thereof then without this plane conduct the line AB of 250. fathom, and vpon that line (according to the rules precedent) build one baſtion, and two halfe baſtions taken from the Octogon, and then ſhall you bee at the


C
A
M
L
N
I
K
B
P
R
H
G
Q
S
D
50 100 150 200 250
Scale of 250 Fathom
T
O
V
X

the point A, and from the point A, draw the line AP of 150. fathom, or thereabout, vpon which you may build two halfe bastions; then draw the line PO, vpon which you shall as before build one bastion and two halfe bastions, and so vpon the line OX, and vpon all the others according to the length that they shall be found. But if it should be required, that the Towne-walls should serue for the courtines, the figure following shall be an example either for a part or for all about a towne.

CHAP.

Chap. XII.

Another manner of fortifying irregularly.

SVppoſe that one would fortifie the plane BAP LMNO, but in ſuch haſt, and with ſo little coſt that the towne walls ſhould ſerue round for the courtines, the plane then being taken vpon a faire ſheet of paper, and hauing drawne the line CDEF of 400. fathom, it ſhall be found neceſſary to build vpon the ſame one baſtion two half baſtions and a tenaile, *viz.* the baſtion

F
E
D
C
A
K
B
G
P
H
Scale of 400 Fathom
50 150
100 200 300 400
I
O
L
N
M

E, the two halfe bastions D and F, and the tenaile DC, & hauing drawn the lines round about the town, leauing sufficient space betwene them and the walls to build bulwarkes or bastions, you may take for the length of euery line of defence, that is to say from the flanke of one bastion to the point of another, 100. or 110 fathom and so euery bastion shall bee scowred with musket-shot, as the forts built regularly. This may serue for an example to those who by chance, may haue occasiō to repair or strengthen any part of a towne, wall, or the whole, and for the fortifying of the wall, the earth must be raised in the inside as a rampard.

A TREATISE OF ARITHMETIKE.

CHAP. I.

Addition

SInce that Arithmetike is absolutely necessary, and required in diuers and many Geometricall operations, I haue added the examples following onely to renew and refresh the memorie of those who haue alreadie studied it, and not those who are quite ignorant therin, (commending them to large and ample Treatises together with masters of the science) but for such as by a weake memory haue let slip the habi-

habitude which by practise they had in times past obtaind; who may easily recouer by this short Treatie sufficient knowledge to performe any ordinary operation beginning with Addition, which is a collection of many numbers in one, as hee who would adde together the numbers ABC, following to haue the summe D, must begin with the first colon:

6	4	1.	A
	3	5.	B
		2.	C
6	7	8.	D

And say 2 and 5, or 7 and 1 is 8, and set 8 vnder the line, as appeares by the example aboue, then in the second colon, say 3 and 4 or 7, and pose them as before; afterward say for the

the 3. colon 6. are fixe, & posing or setting the numbers collected directly vnder the figures not collected as 8 vnder 2, and 7 vnder 3, and fixe vnder fixe, but if any should bee aboue the number of 9, then to set 0 in the place, and set forward all the tens.

The Proofe.

MAy be made in casting all the 9 away, though many times fals but by substraction is the way most certaine, as thus, begin with the last collon and say 6, cut of 6. rest nothing, and giue the 6 vnder the line a slash, then 4 and 3, or 7 and 7, out of

of 7 rest nothing, and as before giue it a slash, then 1,5 and 2, or 8, which as before shall be made nothing, the 8 vnderneath.

Chap. II.

Substraction.

Substraction is to take away a little number from, or out of a greater, as if one would from 8642 take away 4321, then must the numbers bee disposed as followeth, the greater number vppermost, and the lesser vndermost, then draw a line:

Great

Great number	8642. A
Lesser number	4321. B
rest	4321. C

And say he that of 2 in the rank paieth one, rests 1, the which set vnder the line, then of 4 pay 2, rests 2, which must also bee set vnder the line, and who payes 3 out of 6. rests 3. setting them as before, then 4. out of 8 rests 4. which shall bee also set as the others in the example aboue.

The Proofe.

IS made in adding the lesser number B with the rest C as followeth.

Little nummer.		4321
	rest	4321
Great number.		8642

And the sum shall be the first number A, if the substraction haue beene well made.

Chap. III.

Multiplication.

MVltiplication is the assumption of one number, as many times as the other, containeth in itselfe vnities.

652
4
2608

As if one would multiply 6. by 3, that is, to take as oft 6 as 3 containes vnities, as in the example aboue, where

where 2 taken 4 times makes 8, and 5 taken 4 times makes 20. so that the number A multiplied by the nũber B multiplicator 4 times comprehended, make the product 2608.

The Proofe.

THIS made onely diuiding the product 2608 by the multiplication 4 and the quotient will be 652. if the multiplication were well made, as appeares in the example following.

2
2608(652
44
2

CHAP.

Chap. IV.

Diuision.

Diuision is the separation of a number into *aliquot partes* thereof, as to diuide 5689 by 25. the figures must be disposed, as followeth, *viz.* the diuisor vnder the first figures of the number, which is to be diuided, as for example.

5689 (
25

And after the last figure of the number, shall bee drawne a halfe circle to separate the quotient. The numbers

nũbers being thus disposed, then say 2 in 5 how many times, and it shall be found twice; then set 2 behind the halfe circle as in the first example following; and then say twice 2. are 4 of 5 rests 1, dashing out the 2 and the 5. and set the 1 ouer 5, and say againe twice 5 are 10. and strike out the 5 diuisor vnder the 6. and also the 1. ouer the 5, then set forward your diuisor one figure more as in the second example, and say 2 in 6. how how many times, and it shal be found 2, and say twice 2 are 4, and 4 out of 6. rests 2. which shall be set ouer the 6, then say twice 5 re 10. and 10. out of 18. rests 8 and 1 out of 2. rests 1. then dash out the 2. and set 1. ouer it; and also dash out the 5 and 2. diuisors, and set more forward the diuisors, as in the third example, and

say 2 how many times 18. and it shall be found 7. times, and having set the 7, say 7 times 2 is 14. and 14 out of 18 rests 4, and set the 4 ouer the 8; and to conclude, say 7 times 5 are 35, and 35 out of 39 rests 4, and 3 out of 4 rests 1, and so your diuision is ended, as appeares here following by three examples one of each operation.

	1	1 1	
1	12	1244	$\frac{14}{25}$
5689(2	5689(22	5689(227	
25	255	2555	
	2	22	

The

The Proofe.

Multiplie the quotient 227. by the diuisor 25, and to the product partiall, adde the numbers which rest, *viz.* 14. if any rest, and then adde the whole together, and the product shall be the first number if the diuision hath beene well made as in the example following.

227
25

1135
454
14

5689

CHAP. V.

Rules of Fractions.

A Fraction is a number noting the *partes aliquot* of an entire or whole number, whereof it is said to be a fraction as a penny, the twelfth part of a shilling, one inch the foure and fortieth part of an Ell, &c.

CHAP. VI.

How to rednce intiers and Fractions all into Fractions.

TO reduce $8\frac{3}{4}$ and $5\frac{2}{3}$ all in fractions you must multiplie 8 by 4, saying 4. times 8 is 32, and the 3 being added, makes 35, which shall be set aboue a line iust vnder the first figures, and vnder that line set 4, as in the example following, to shew that the 45 are al fourth parts, and doe in the like manner by the $5\frac{2}{3}$, and say 3 times 5 are 15, and 2 makes 17. and so you shall haue 17. thirds, as in the example following.

To reduce $8\frac{3}{4}$ and $5\frac{2}{3}$ all into fractions.

$$\frac{35}{4} \qquad \frac{17}{3}$$

Chap. VI.

To reduce all fractions into one denomination.

TO bring these two fractions to one deno. the 35 quarters numerators must bee multiplied by the other numerators 17. thirds, and set the product ouer a line as here following, then multiply the 4 denominator by the other 3. deno-

denominator, and set the product of those vnder the line, and then will there be,

595
12

Addition of Fractions.

TO adde $\frac{2}{3}$ to $\frac{1}{4}$ the figures, dispose the figures as followeth, and say 3 times 1 is 3, and set the 3. ouer a line aboue the head of the others, and then say 4 times 2 are 8. and set them ouer a line aboue the head of the others also, then say 3 and

8 are 11, and set them ouer a line betweene the first numbers and the 11, shall be numerators, and say 4 times 3 are 12, & set them vnder the middle line, and those shall bee denominators, and so you shall haue eleuen twelfth parts as followeth.

$$\frac{8}{} \qquad \frac{3}{}$$

$$\frac{2}{3} \quad 11 \quad \frac{1}{4}$$

But if the numerator bee greater then the denominator, then it shall bee diuided by the denominator, anc the product shall be an entire or entires, and what resteth (if any rest) shall bee fraction, which ought to be abridged, as appeareth here following.

18 20

$\frac{3}{4}$ $\frac{38}{24}$ $\frac{5}{6}$

Where the numerator 38 is greater then the denominator 24. then being diuided by the denominator 24. doth yeeld 1 intire, and $\frac{14}{24}$ the which being abridged come to $\frac{7}{12}$, which is almost two thirds, and so of all others.

CHAP.

CHAP. VII.

Additions of intiers and fractions.

BEing proposed to 243$\frac{2}{3}$. vnto 462$\frac{1}{4}$. the intiers must be added as in the first chapter of Addition and the fractions must be added as in the precedent chapter, and set product as appeares following.

8		3
2	11	1
3	12	4

CHAP. VIII.

Substraction of Fractions.

WHosoeuer would substract $\frac{2}{3}$ from $\frac{3}{4}$ must dispose the figures, as in the example following; and first multiply the numerators by the denominators a crosse, as 3. times 3 are 9. and 4 times 2 are 8, and set 9 and 8 ouer the lines aboue the heads of the others, and then say take 8 out of 9, and there rests 1, which must bee set ouer a line be-

tweene

tweene both, and afterward say 3. times 4 is 12, multiplying denominators by denominators, and set them vnder the middle line, which shall bee the denominators for the rest, as appeares cleerely in the example following.

Out of 9 pay 8 rest 1

$$\frac{3}{4} \quad \frac{1}{12} \quad \frac{2}{3}$$

Chap. IX.

Subſtractions of intiers and fractions.

TO ſubſtract 183 1/2 from 267 2/3 the fractions muſt firſt be multiplyed as in the example following; and ſay twice 2 are 4, and ſet the 4 ouer a line, then 3 times 1 are 3, and ſet them ouer a line, and then who payes 3 out of 4 reſts 1, which muſt be ſet ouer the middle line, which done, multiply the one denominator by the other, and ſet the product vnder that which doth reſt, as followeth.

Receiued

Receiued	$267\frac{2}{3}$	$\frac{4}{-}$		$\frac{3}{-}$
	$183\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{6}$	$\frac{1}{2}$
Rests	$84\frac{1}{6}$			

But if the fraction of the receiued should be lesse then the fraction of the summe paid, then must there be one borrowed from the whole or intire number, and count it according to the denomination of the fraction, for if the denominator bee 4, then shall the intier be $\frac{4}{4}$, if 5, then $\frac{5}{5}$, if 6 then $\frac{6}{6}$, &c.

CHAP.

Chap. X.

Multiplication of Fractions.

Let there bee propoſed a ſuperficies in the forme of a paralellogram, vulgarly cald ſquare, the ſides whereof the one is in length $\frac{7}{8}$ of a fathom, and the other in breadth $\frac{3}{4}$, and theſe two fractions are to bee multiplied together to find out how much the whole ſuperficies doth containe the figures muſt be diſpoſed as followeth.

$\frac{7}{8}$

$\frac{3}{4}$ $\left[\frac{21}{32}\right]$ multiply $\frac{7}{8}$ $\frac{21}{32}$ by $\frac{3}{4}$

And

And multiplie one numerator by the other numerator, and then one denominator by the other denominator, saying 3 times seuen is 21, and set them ouer head, then foure times 8 is 32, and set them vnderneath, and the whole will bee $\frac{21}{32}$ parts of a fathom, which certainely containeth the required superficies.

CHAP.

Chap. XI.

Multiplication of entiers and Fractions.

TO multiply $\frac{1}{4}$ by $2\frac{1}{2}$, you must first of al reduce the whole into fractions, and then as here aboue multiply numerator by numerator, and denominator by denominator, and the product will bee $\frac{45}{8}$, as plainely appeares by the example following.

$$2\frac{1}{4} \text{ by } 2\frac{1}{2}$$

$$\frac{9}{4} \quad \frac{45}{8} \quad \frac{5}{2}$$

But if it were proposed to multiply greater numbers, as 20 by $15\frac{26}{29}$, then multiply the 15. intiers by the deno. 29. of the fraction, & then adde the numerator 26 of the same fraction; which done will mount to $\frac{461}{29}$, then set the 461 ouer a line, and the 29. vnder it, and afterward multiply the 20 intiers by the 461. which done, diuide the product of the whole by the denominator 29. and the num. qer required shall bee $317\frac{27}{29}$, as appeares:

20 by $15\frac{26}{29}$

$$\begin{array}{r} 461 \\ 20 \\ \hline 9220 \end{array}$$

$$\begin{array}{r} 22 \\ 39 \\ 3537 \\ 9220 \\ 2998 \\ 22 \end{array} \quad (317\tfrac{27}{29}$$

$$\frac{20}{1} \qquad \frac{461}{29}.$$

CHAP.

CHAP. XII.

The diuision of Fractions.

TO diuide $\frac{3}{4}$ by $\frac{2}{3}$, each numerator is to bee multiplied by each denominator opposite, and set the product ouer a line aboue them, and then diuide the greatest product by the least as followeth.

CHAP. XIII.

To diuide intiers and fractions by intiers and fractions.

TO diuide $12\frac{2}{3}$ by $3\frac{1}{6}$, they must first be reduced all into fractions as before, and then you must multiply the numerators by the denominators acrosse as followeth, and then diuide the greatest product by the least, as this example doth cleerely demonstrate.

$\frac{228}{\quad}$ $\frac{57}{\quad}$ diuision 228(4

57

Chap. XIV.

Evaluation of fractions which may not be abridged.

Svppose you were to abridge $\frac{7}{9}$ parts of a fathom, first you must consider what are the parts of the intier or whole, as 6. foot, or 72. inches: then you must multiply the numerator 7, by the denominator 72 parts, and let the product bee diuided by the denominator 9, and then you will finde 56 inches for the evaluation of $\frac{7}{9}$ parts of a fathom.

$$\begin{array}{r} 72 \\ \underline{7} \\ 504 \end{array} \quad \text{diuision} \quad \begin{array}{r} \cancel{5} \\ \cancel{5}\cancel{0}\cancel{4}(56 \\ \cancel{9}\cancel{9} \end{array}$$

By this meanes any fraction may be abridged as well in Geometrie as as commerce, although they seeme not to be abridged.

CHAP. XV.

For the eualuation of measuring lands.

YOu must consider that the fathom of 6 foot in length, doth containe in superficies 36. and that he

the 72 inches in length doth contain in superficies 5184 inches, and of other measures then to valuate a fraction of $\frac{19}{47}$ parts of a fathom, square in superficies you must multiply 5184 by 19. and diuide the product by 47, and there will be 2095 inches for the square of $\frac{29}{47}$ of a fathom square and so of other like measures.

CHAP. XVI.

Of the rule of three without fractions.

MVltiply the second number 400 by the third 12. and product 4800 by the first number 4, and the quotient shall be the number required, and dispose your rule as followeth.

months---pounds--months.
If in 4-----400---------12

The

The probation of this Rule.

IS to multiplie the firſt number 4 by the fourth number 1200, and to multiplie the ſecond by the third, and the two products will bee equall if the rule bee well made.

Chap. XVII.

Of the rule of three with intiers and fractions.

First all the intiers must bee reduced into fractions as followeth.

yards	pounds	yards.
If $2\frac{1}{4}$	$12\frac{1}{2}$	$7\frac{1}{2}$
$\frac{9}{4}$	$\frac{25}{2}$	$\frac{15}{2}$

Which done, you must multiply the second number of fractions as by the

the third number of fractions 15, & then againe multiply the product by 4 the denominator of the first number, and then say 2 times 2, or 4, and 4 times 9 is 36, which must bee set vnder the line, by which you shal diuide the first product 1500, and the quotient shall be the number required, as appeares,

25	
15	2
125	3
25	364
375	1500 (41 24/36
4	360
1500	3

Heere followeth two examples, differing the one from the other; whereof the manner of multiplying the one, is more easier then the other the first is multiplyed as the precedent, but the last is multiplied first by

by all the intires, viz. by 3, by 8, and by three, leauing the fraction $\frac{1}{3}$ by it selfe, and after all take the third of the intier, viz. of 50000, saying the third part of 5 is one rest 2, for the 10 which is valuated at 20, then say the third part of 20 is 6, and so rests 2 for the second 0, and so to the end, and what shall rest at last, shall be set ouer a line, and your 3 4th or 5 vnder the line, then all being added together, you shal diuide the product cutting off the figures to the quantitie of the first number, saying, by ten, by a hundred, by a thousand, by ten thousand, by a hundred thousand, & the remainder is the number required, as appeareth, $191\frac{2}{3}$.

The

The first example.

If 100000 ---- $383\frac{1}{3}$ ---- 50000.

100000	1150	50000.
1	3	1

The second number being multiplied by the third, doth mount to 57500000, and being diuided by the first multiplyed by 3, as before is taught, the quotient will be $191\frac{2}{3}$.

The

The second example.

IF 100000—383$\frac{1}{3}$—50000

383$\frac{5}{7}$

150000
400000
150000
166 66$\frac{2}{3}$

191, 6, 6, 6, 6, 6$\frac{2}{3}$

CHAP.

Chap. XVIII.

Extraction of the ſquare roote.

FIrſt diſpoſe your numbers as followeth out of which you meane to draw the roote ſeparating your figures by two and two beginning at the latter end; but firſt ſtrike the halfe circle 73|21|01 (and then ſay the root of 73 is 8, and ſet 8 before the half circle, & reſts 9, then double the quotient 8, and ſay 2 times 8 are 16, and ſet the 6 vnder the laſt figure of the ſecond part of figures, and 1 vnder

der the first figure of the first part as in this first example.

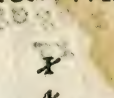
9
75|21|01(8
1 6

Then say how many times is 1 in 9, and it shall be 5. which you shall also set vnder the 1 of the second separation, as appeares in this second example.

1
4
9 96
73|21|01(85
1 65

And then say 5 times 1 are 5, which taken out of 9 rests 4, and 5 times 6 are 30, and 30 out of 32 rests 2, and 3 out of 4 rest 1, and then againe say 5 times 5 are 25, which out of 31 rest

reſt 6. and 3 out of 12 reſt 9. and then double the quotient, and ſay twice 5 are 10 ſet 0 vnder 0 of the laſt ſeparation, and keepe 1 in memorie, and ſay twice 8 are 16, and 1 that I keepe in mind makes 17, then ſet downe 7 vnder the 5, and the 1 vnder the 6 of the middle ſeparation, as appeares in this example following.



And then ſay how many times is 1 in 9 and it ſhall be 5 times, which ſhall be ſet downe for quotient, and alſo vnder the laſt figure 1, and then ſay 5 times 1 are 5, out of 9 reſts 4, and 5. times 7 are 35, which out of

36 rests 1, and 3 out of 4 rests 1, and 5 times 0 is 0, and 5. times 5 are 25. out of 31 rests 6, & 3 out of 10 rests 7, and 1 out of 1 rests 0, and so the rule is ended as appeares following.

```
 1 1 0
 4 4 1
 6|6 6|7 6
73|2 1|0 1(855
 1 6 5 0 5
   1 7
```

CHAP. XIX.

Another example of the square root.

```
      2
2     7 8
6   |3 2|6 9 (251 269/505
    |4 5|0 1
      5
```

After you haue separated your figures

gures by two and two, and drawne 251 the square roote, there doth yet rest 268, which must bee reduced into fractions, and to begin set that rest 268 ouer a line at the end of your root, and that rest shall be numerator of the fraction; and to finde the denominator only, double the root 251 if it be bigger then the rest, but if lesse as here, adde one to the doubling of the first figure, saying twice 1 is 2, and 1 that I adde makes 3, adde only double the rest, and set it vnder the line, and that shall be the denominator of the fraction; and to haue the root of this fraction here aboue, first take the root of the numerator, and set that root ouer a line, and it shall be numerator as appeares following.

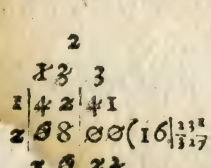
```
      1
  2 | 4 2
  2 | 6 8 (16
      2 6
```

Then draw roote of the denominator, and set it vnder the line, and that shall be a denominator, and so you shall finde $\frac{16}{22}$, and what rests is vnsensible.

```
      1
  1 | 2   9
  5 | 0   3 (22
      4   2
```

But because that this fraction $\frac{16}{22}$ is not precisely perfect, and that there is a rest in each extraction, you may operate as followeth to haue it mooue exactly, adde as well to the numerator as to the denominator two, oo, or foure, or sixe, &c. and from each product

duct or quotiēt out of one figure for euery two oo which you shall haue added, and the more that you adde oo, the more precisely you shall haue the roote as appeares following.



But if it were proposed to extract the square roote of $\frac{6}{25}$, there would nothing rest, nor would it bee needfull to adde any oo, for the root of 16 is 4 and the root of 25 is 5, and so wee should haue $\frac{4}{5}$, and the like in all such other accidents; and thus much for Arithmetike. *Vale.*

FINIS.

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